

Atlantic Richfield Company

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August 29, 2012

Mr. Steven Way On-Scene Coordinator Emergency Response Program (8EPR-SA) U.S. EPA Region 8 1595 Wynkoop Street Denver, CO 80202-1129

RE:

St. Louis Tunnel Discharge Constructed Wetland Pilot Scale Test Work Plan Rico-Argentine Mine Site – Rico Tunnels, Operable Unit OU01

Dolores County, Colorado

Dear Mr. Way:

On behalf of Atlantic Richfield Company (Atlantic Richfield), please find enclosed the St. Louis Tunnel Discharge Constructed Wetland Pilot Scale Test Work Plan (Work Plan) prepared for the Rico-Argentine Mine Site (site). This Work Plan notifies the United States Environmental Protection Agency, Region 8, (U.S. EPA) of Atlantic Richfield's plans for constructing a pilot scale passive treatment system to evaluate the treatability of mine water discharging from the St. Louis Tunnel. Atlantic Richfield requests U.S. EPA's approval of this Work Plan pursuant to requirements in Task F - Water Treatment System Analysis and Design / Subtask F2 -Treatment System Conceptual Designs and Additional Investigations of the Remedial Action Work Plan accompanying the Unilateral Administrative Order for Removal Action, Rico-Argentine Site, Dolores County, U.S. EPA Region 8, dated March 9, 2011 (Docket No. 08-2011-0005).

If you have any questions regarding this Work Plan, please feel free to contact me at (714) 228-6770 or via e-mail at Anthony.Brown@bp.com.

Sincerely,

Tony Brown

Project Manager Mining Atlantic Richfield Company

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Enclosures: St. Louis Tunnel Discharge Constructed Wetland Pilot Scale Test Work Plan



Mr. Steven Way U.S. EPA Region 8 August 29, 2012 Page 2 of 2

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ST. LOUIS TUNNEL DISCHARGE CONSTRUCTED WETLAND PILOT SCALE TEST WORK PLAN Rico-Argentine Mine Site – Rico Tunnels Operable Unit OU01 Dolores County, Colorado

August 2012

Project SA11161301



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ABBREVIATIONS

AMEC Environment & Infrastructure, Inc.

Atlantic Richfield Atlantic Richfield Company

ARAR Applicable or Relevant and Appropriate Requirement

BOD biological oxygen demand

DO dissolved oxygen gpm gallon per minute

HSSE Health, Safety, Security and Environment

mg/L milligram per liter
Mn manganese
MnO₂ manganese oxide

mV milliVolt

ORP oxidation reduction potential

ppm part per million

PWTASR Preliminary Water Treatment Alternatives Screening Report

RAWP Removal Action Work Plan

site Rico-Argentine Mine Site – Rico Tunnels, Operable Unit OU01, Dolores

County, Colorado

SOP Standard Operating Procedure SRB sulfate-reducing bacteria

s.u. standard units

TSEAs Task Safety Environmental Analyses

TOC total organic carbon

UAO Unilateral Administrative Order

U.S. EPA U.S. Environmental Protection Agency

Work Plan St. Louis Tunnel Discharge Constructed Wetland Pilot Scale Test Work

Plan

°C degree Celsius °F degree Fahrenheit



ST. LOUIS TUNNEL DISCHARGE CONSTRUCTED WETLAND PILOT SCALE TEST WORK PLAN

Rico-Argentine Mine Site – Rico Tunnels
Operable Unit OU01
Dolores County, Colorado

1.0 INTRODUCTION

AMEC Environment & Infrastructure, Inc. (AMEC), on behalf of Atlantic Richfield Company (Atlantic Richfield), presents this *St. Louis Tunnel Discharge Constructed Wetland Pilot Scale Test Work Plan* (Work Plan) to evaluate the treatability of mine water discharging from the St. Louis Tunnel as a potential final treatment, or polishing step. The site is located in the San Juan Mountains of southwestern Colorado, just north of the Town of Rico in Dolores County, Colorado (Figure 1). The site consists of the St. Louis Tunnel and associated complex of underground mine-workings, as well as a series of settling ponds. A general site layout is presented in Figure 2.

This Work Plan is developed pursuant to Task F Subtask F2 of the *Removal Action Work Plan* (RAWP) attached to the *Unilateral Administrative Order* (UAO) issued to Atlantic Richfield by the U.S. Environmental Protection Agency (U.S. EPA) on March 9, 2011 (Docket No. 08-2011-0005) (U.S. EPA, 2011) for the Rico-Argentine Mine Site – Rico Tunnels, Operable Unit OU01, Dolores County, Colorado (site). The RAWP requires that design studies be performed following the completion of a Preliminary Water Treatment Alternatives Screening Report (PWTASR) in order to compare alternatives and support water treatment system designs. The PWTASR was submitted to EPA in November 2011 and identified a number of data gaps pertaining to the screening of technologies and alternatives.

The Rico-Argentine Mine and related workings produce an acidic drainage that requires treatment in order to protect the water quality of the Dolores River and comply with the Applicable or Relevant and Appropriate Requirements (ARARs) defined in the *Action Memorandum* (U.S. EPA, 2010) for the site. High acidity and metal loads are contributed to the St. Louis Tunnel discharge in part by the Blaine Tunnel and upper mine workings, but subsequent flow of this water through the mine workings results in dilution and partial neutralization by predominantly carbonate minerals, thereby improving water quality. Although the discharge from the St. Louis Tunnel has a circum neutral pH, it contains elevated concentrations of manganese (Mn), cadmium, zinc, and iron (total).



Treatment of acidic water upgradient of the St. Louis Tunnel portal through injection of potassium carbonate into the 517 Shaft is the subject of the proposed *St. Louis Tunnel Discharge Source Mine Water Treatability Test Work Plan*. Based on a review of existing water quality data, AMEC has concluded that alkaline addition may not sufficiently remove manganese, cadmium, and zinc unless water pH is raised to greater than 10 standard units (s.u.). Thus, an upgradient alkaline treatment system may require additional treatment, or "polishing", of the St. Louis Tunnel discharge to reduce manganese, cadmium, and zinc to acceptable concentrations prior to discharge to the Dolores River.

Manganese, cadmium, and zinc are amenable to passive treatment. Biological and chemical oxidation can remove manganese from neutral drainage, while biological sulfate reduction can remove cadmium and zinc. Therefore, AMEC proposes to assess the feasibility and performance of a passive treatment system at the site by conducting a pilot-scale test of an aerobic rock drain for manganese removal, followed in series by an anaerobic subsurface flow constructed wetland for cadmium and zinc removal. Additionally, AMEC proposes limited bench-scale testing to further evaluate additional passive treatment alternatives.

1.1 HEALTH, SAFETY, SECURITY, AND ENVIRONMENT EXPECTATIONS

All tasks described herein will be performed in accordance with the Task Specific Health, Safety, Security, and Environment (HSSE) Plans prepared by Atlantic Richfield's contractors. The appropriate Risk Assessments, Task Safety Environmental Analyses (TSEAs), Standard Operating Procedures (SOPs), and permits will be completed prior to initiating any of the work described herein.

1.2 DOCUMENT ORGANIZATION

Following the introduction, this Work Plan is organized into the following sections:

- Section 2 presents a brief summary of site background and historical information.
- Section 3 presents the pilot-scale test objectives.
- Section 4 describes the process chemistry related to implementation and assessment of the proposed passive treatment system.
- Section 5 presents anticipated site limitations and recommended solutions.
- Section 6 presents the rock drain pilot-scale test plan for manganese removal.



- Section 7 presents the anaerobic subsurface flow constructed wetland pilot-scale test plan for cadmium and zinc removal.
- Section 8 outlines the schedule for completing the work.
- Section 9 specifies the evaluations and data reduction that will be reported during and after completion of the tests.
- Section 10 outlines the planned reporting throughout the proposed pilot testing campaign.
- Section 11 lists references used in preparing this Work Plan.

2.0 BACKGROUND

The Rico-Argentine Mine Site is located approximately 0.75 mile north of the Town of Rico in Dolores County, Colorado (Figure 1). The site lies at the base of Telescope Mountain in a relatively flat area adjacent to the Dolores River (Figure 2) and consists of a complex of underground workings and facilities associated with the Rico-Argentine Mine, including a series of settling ponds located downgradient of the St. Louis Tunnel portal. The average elevation at the St. Louis Tunnel is approximately 8,800 feet above mean sea level.

In 1930 to 1931, the St. Louis Tunnel was driven by the St. Louis Smelting & Refining Company, a division of National Lead Company. Later in the 1930s, the "northwest crosscut" was driven to connect the St. Louis Tunnel to the Mountain Spring-Wellington Mine. Given the geologic and groundwater conditions within Telescope Mountain, this tunnel is assumed to have become a source of mine water discharge to the Dolores River. Construction of the St. Louis Ponds system is believed to have begun about the same time as the driving of this crosscut. In 1955, the "southeast crosscut" was driven to connect the St. Louis Tunnel with the Argentine Mine on Silver Creek. This presumably resulted in additional mine water discharges to the Dolores River, as additional interconnected mine workings and faulted/fractured bedrock were intercepted along this new crosscut.

The site has three primary locations from which mine water can be intercepted: the St. Louis Tunnel, the 517 Shaft, and the Blaine Tunnel (Figure 2). Some portion of the drainage from these areas and the mine workings above them flows along the crosscuts and into the St. Louis Tunnel before discharging to the St. Louis Ponds system. Flow from the St. Louis Tunnel discharge has been observed to vary seasonally and annually, with observed flow



rates ranging from 265 gallons per minute (gpm) to 2,200 gpm. The average flow rate for the St. Louis Tunnel discharge is approximately 750 gpm (based on available data from 1973 to 2012).

3.0 PILOT-SCALE TEST OBJECTIVES

As discussed in Section 1.0, this Work Plan describes the proposed design and implementation of a constructed wetlands pilot-scale test for potential passive final-phase treatment of the St. Louis Tunnel discharge. The primary objectives of this pilot-scale test are to:

- 1. Determine the treatment performance attainable through passive treatment of the St. Louis Tunnel discharge;
- 2. Determine the surface area required for full-scale treatment; and
- 3. Develop preliminary design criteria and evaluate this alternative for a passive water treatment system.

To achieve these objectives, AMEC proposes to develop a passive treatment system that combines an aerobic rock drain with an anaerobic subsurface flow wetland operated in series (Figure 3). The aerobic rock drain will be designed to remove manganese, while the anaerobic constructed wetland will be designed to promote biological sulfate reduction for removal primarily of cadmium and zinc. This pilot-scale system will be sized to treat flows of 1 gpm to 10 gpm.

There are demonstrated design criteria available for aerobic wetlands designed to remove manganese (Hedin et al., 1994). Similarly, there are several examples throughout North America of bioreactors or wetlands that remove cadmium and/or zinc (Sobolewski, 1999). Therefore, it is not necessary to conduct bench-scale tests to provide a proof-of-concept for these treatment processes.

Pilot-scale testing will allow the project team to relate treatment performance (as metal removal rates) to system residence times and identify any operational problems associated with passively treating St. Louis Tunnel discharge. Pilot testing also will allow the project team to analyze the fate of metals retained in the system. The components of the proposed pilot-scale passive treatment system are discussed in more detail in the following sections.

In addition to the pilot-scale testing, Atlantic Richfield will also be conducting limited bench scale testing to further evaluate other passive treatment alternatives (i.e., bioreactors) for



treating the discharge from the St. Louis Tunnel as part of this work. This bench testing will be used to evaluate a number of issues at the bench-scale (i.e., carbon addition rates, growth media, and potential for colloidal particulate formation requiring additional polishing) and develop preliminary estimates of full-scale area requirements to evaluate the feasibility of other passive treatment alternatives.

4.0 PROCESS CHEMISTRY

Pilot-scale testing will be used to evaluate a number of biological and chemical processes. The specific processes that will be used in the rock drain and the subsurface flow constructed wetland are discussed in detail below.

Manganese can be removed from solution at circumneutral pH by forming insoluble manganese oxide (MnO₂) following either of two processes:

- 1. Autocatalytic chemical oxidation of dissolved Mn(II) to MnO₂, or
- 2. Biological oxidation of dissolved Mn(II) to MnO₂.

The first reaction provides the basis for the greensand treatment process, whereby manganese oxide-coated sand is used as a medium to promote removal of dissolved iron, manganese, and other constituents. The second reaction is exploited in aerobic rock drains and treatment wetlands, whereby dissolved manganese is oxidized into insoluble manganese oxide by bacterial mediation. In the absence of either manganese oxide or manganese-oxidizing bacteria, manganese can be removed as a carbonate or other compound when the solution pH exceeds 10 s.u. In practice, passive treatment is obtained in aerobic wetlands or simple rock drains that have been seeded with manganese oxides or manganese-oxidizing bacteria.

The oxidation of manganese requires that dissolved iron (as ferrous iron) is absent from mine drainage, because ferrous iron reduces Mn(IV), thereby dissolving manganese oxide. Thus, manganese removal must be conducted after ferrous iron is removed from the St. Louis Tunnel discharge. Currently, the St. Louis Ponds system provides some means for iron removal from the St. Louis Tunnel discharge. Treatment of acidic water upgradient of the St. Louis Tunnel portal is the subject of ongoing investigations.

The formation of (hydrous) manganese oxides provides an additional benefit: (hydrous) manganese oxides present a large sorptive surface area that strongly adsorb metals such as copper, nickel, and zinc.



Cadmium and zinc require different treatment processes than manganese because they are mobile in acidic or circumneutral oxic waters. In addition, permitted effluent requirements typically necessitate much lower cadmium and zinc concentrations sub-part per million (ppm) than manganese concentrations due to their toxicity.

Both cadmium and zinc react strongly with aqueous sulfide to form insoluble compounds (Table 1). According to this table, the dissolved concentrations of cadmium and zinc can be reduced to less than 10⁻¹⁰ ppm at equilibrium in the presence of hydrogen sulfide. Although theoretical equilibrium concentrations are not typically attained in a treatment system, these values do indicate that sub-ppm concentrations of dissolved cadmium and zinc may be achievable.

The formation of insoluble metal sulfides is the treatment process used in bioreactors or anaerobic wetland sediments that promote biological sulfate reduction, and there are several examples of such systems for treatment of cadmium and/or zinc (Sobolewski, 1999). Treatment to low concentrations requires a means to remove the colloidal metal sulfides that form when the inflow metal concentrations are very low (i.e., less than 1 to 2 ppm). In practice, this is achieved by promoting sulfate reduction in an organic-rich matrix, where the organic matter provides attachment sites and nutrients for sulfate-reducing bacteria (SRB) as well as filtration/retention of the resulting metal sulfides.

5.0 SITE LIMITATIONS AND RECOMMENDED SOLUTIONS

While the geochemistry and process chemistry do indicate that conditions at the site are favorable for passive treatment of mine drainage, there are two primary limitations to the oxidation and biological sulfate reduction processes that must be addressed: required land area and water temperature. These limitations and recommended solutions are discussed below.

5.1 REQUIRED LAND AREA

The primary challenge in passively treating the large flows discharging from the St. Louis Tunnel is sufficient siting and appropriate land area. Assuming design flows of 1,000 gpm for a full-scale system, preliminary calculations indicate that an area of seven to ten acres of gently-sloping land will be required for passive treatment of manganese, cadmium, and zinc.

There are approximately 20 acres on site downstream from the St. Louis Tunnel discharge and approximately nine acres along the existing pond system between Pond 10 and Pond 4 in which passive treatment systems may be situated. While this is less than the ten-acre



estimate of required land area, pilot testing may indicate whether the available nine acres will suffice, given site-specific removal rates. Removal rates observed under field conditions vary by site based on elevation, water temperature, chemistry, and other site-specific parameters.

5.2 WATER TEMPERATURE

Biological sulfate reduction does not proceed well at cold temperatures, as related to the degradation of organic carbon and sustenance of biological activity inside a wetland. For the purposes of this Work Plan, "cold temperatures" are defined as water temperatures less than 10 degrees Celsius (°C), 50 degrees Fahrenheit (°F). Temperatures above 10°C are considered to be acceptable to biological sulfate reduction, while "warm temperatures" between 15°C and 20°C (60°F and 70°F) are preferred. Water temperatures from the St. Louis Tunnel discharge have been observed to range from approximately 6°C to 21°C at the sampling location "DR-3". These temperatures are assumed to decrease as water flows through the settling ponds. Therefore, it is anticipated that seasonal temperature adjustment will be required.

To increase the system temperature during this pilot test, AMEC proposes to install commercially available heat trace circuits around the system inlet control box and piping and through the rock drain and wetland matrices to prevent freezing/icing of the system during the winter and to maintain elevated water temperatures that are more favorable to biological sulfate reduction. Plastic insulating balls will be placed over the surface of the rock drain to provide an additional temperature barrier. Mulch will be placed over the surface of the constructed wetland to both insulate and protect the wetland substrate.

It is noteworthy that full-scale implementation of a rock drain and/or constructed wetland would likely involve simply comingling geothermal water from the exploratory core holes located on site with the system influent to increase the temperatures. However, doing so is not recommended for this pilot test, where influent flow rates will be varied to characterize optimal system performance. While using different approaches for pilot testing and full-scale implementation is typically undesirable, impacts to system performance due to comingling St. Louis Tunnel discharge with geothermal water are anticipated to be insignificant for purposes of this pilot. Using heat trace circuits for the pilot test will provide a fair representation of temperature effects, while separating the question of temperature from those of residence time and chemical mixing.



6.0 ROCK DRAIN FOR MANGANESE REMOVAL

The following subsections present the design parameters and method for inoculating the rock drain. Additionally, the methods for evaluating the treatment performance of the rock drain are discussed.

6.1 DESIGN PARAMETERS

The rock drain for manganese removal will consist of a shallow drain with relatively uniformly-sized rock that will be seeded with manganese oxide and/or manganese-oxidizing bacteria. The rock drain will be constructed along the western portion of the Pond 9 footprint, downgradient of Pond 11. The final rock drain location will be selected based on available land, topography, accessibility, and sources of water. The rock drain dimensions are anticipated to be 2 feet deep, 14 feet wide, and 30 feet long (Figure 3). These dimensions are based on previous experience with similar systems designed and operated by AMEC¹.

The excavated bed will be lined with an impermeable geomembrane (or suitable alternative) unless soils are found to be clayey and relatively impermeable. The geomembrane will minimize water loses to the ground but will not completely seal the rock drain. The excavated area will be filled with 1- to 2-inch nominal cleaned river rock that will have been mixed with manganese oxide inoculum (described below). A slipstream from the Pond 11 discharge will be routed to a flow control box, from which the rock drain influent will be directed to the treatment system at the desired flow rate.

One monitoring port (perforated riser) will be installed inside the rock matrix near the rock drain outlet/wetland inlet to assess operational parameters. Additional monitoring ports may be installed as needed.

The rock drain design will incorporate elements to minimize or prevent ice formation in the system, thereby enabling winter operation, including overlying the drain with insulating plastic balls and running a heat trace circuit through the rock matrix, as discussed in Section 5.2.

¹ For example, the pilot-scale rock drain treating manganese from landfill leachate at the Eurocan Mill.



6.2 ROCK DRAIN INOCULUM

Manganese oxide and/or manganese-oxidizing bacteria used to seed a rock drain typically are found in shallow (aerated) sediments located downstream from settling ponds that remove iron but not manganese. The discharge from these areas is depleted in dissolved manganese, but the sediments contain characteristic black, granular surface deposits indicative of manganese oxide. Typically, these deposits contain manganese-oxidizing bacteria. One such location has been identified on site; laboratory analysis of the proposed inoculum



Black surface deposit characteristic of manganese oxide.

indicates that a sufficient source of manganese-oxidizing bacteria is present.

The rock matrix will be inoculated during construction of the rock drain. A bacteria colonization period of approximately three to four weeks will follow inoculation, during which time the flow rate through the system will be adjusted to approximately 1 gpm. It is anticipated that pilot testing will commence when oxidation reduction potential (ORP) is measured to be less than -100 milliVolts (mV) in the wetland.

6.3 Performance Evaluation

Before the pilot test begins, rock used in the drain will be photographed to document colonization of manganese oxidizing bacteria, and an inoculate grab sample will be collected and analyzed for initial metals concentration. After pilot testing, samples of the rock matrix will be collected and acid-washed to dissolve any metals coating the rock surface. Acid-wash water will be filtered and analyzed for total and dissolved metals concentrations to quantify and document the extent of manganese (and other metal) accumulation on the rock surfaces. This information will be used to estimate the total mass of metals accumulated inside the rock drain, as well as to calculate a mass balance between inflow and outflow metal loads.

Treatment performance will be determined by sampling (1) influent water from Pond 11 at the rock drain inlet and (2) treated water near the wetland inlet. Monitoring parameters will include influent flow rate, water pH, specific electrical conductance, temperature, ORP, dissolved oxygen (DO), total sulfate, total dissolved sulfide, and total and dissolved metals. Although the rock drain will be designed primarily for manganese removal, monitoring will also be conducted to detect possible removal of other metals adsorbed onto manganese oxides.



Metal removal rates will be determined as a function of residence time, which will be determined by flow rates. Nominal hydraulic residence times that are calculated based on design assumptions will be confirmed through tracer studies conducted during pilot testing.

7.0 ANAEROBIC SUBSURFACE FLOW CONSTRUCTED WETLAND

The following subsections present the design parameters and methods for evaluating the treatment performance of the constructed wetland.

7.1 DESIGN PARAMETERS

The constructed wetland will consist of an excavated bed filled with a permeable organic matrix planted with wetland vegetation (i.e., emergent macrophytes). The system will be designed to promote bacterial sulfate reduction, which produces hydrogen sulfide, and precipitate cadmium and zinc as insoluble sulfides. These insoluble sulfides will accumulate within the organic matrix during the life of the wetland.

The wetland will be constructed in a suitably flat location within the Pond 9 footprint, downgradient of the rock drain. The pilot test wetland dimensions are anticipated to be approximately 2.5 feet deep, 14 feet wide, and 70 feet long (Figure 3).

The excavated wetland bed will be lined with an impermeable geomembrane (or suitable alternative) unless soils are found to be clayey and relatively impermeable. This geomembrane will minimize but will not completely eliminate water loses to the ground. The wetland will be operated in a subsurface flow configuration: water channeled from the St. Louis Tunnel discharge will flow predominantly through the roots and support matrix. The organic matrix will consist of a mix of inert rock, wood chips/mulch, nutrient-rich manure, sulfur prills, and liquid fish fertilizer. Limestone may be added to the river rock matrix if readily available. The composition of this mix will be dictated by the availability of materials as well as long-term permeability. The proportion of each constituent is presented in Table 2.

Wood chips from deciduous trees, such as Aspen or Cottonwood, will be produced on site using a wood chipper or obtained from an outside source. Pine wood chips may be used if readily available.

Prior to filling the excavated area with the wetland substrate, the substrate will be inoculated and thoroughly mixed with sediments containing SRB. If local sources of SRB cannot be



identified, the bacterial inoculum will be obtained from off-site sources². A bacteria colonization period of approximately three to four weeks will follow inoculation, during which time the flow rate through the system will be adjusted to approximately 1 gpm. It is anticipated that pilot testing will commence when ORP is measured to be less than -100 mV in the wetland.

The wetland will be vegetated with plants obtained from stands near the site, which will be identified by field personnel prior to implementation of this Work Plan. Plant species used in the wetland will be selected based on the characteristics of their growth habit, such as deep and ample root growth, abundance, and accessibility. Four to six inches of landscaping (noncedar) mulch will be placed at the surface of the wetland to provide insulation and promote anaerobic conditions within the wetland.

Monitoring ports (perforated risers) will be installed inside the organic matrix near the wetland inlet and outlet to assess conditions inside the wetland. These ports will allow sampling of the internal porewater to monitor the development of anaerobic conditions in the organic matrix and the production of hydrogen sulfide. Additional monitoring ports may be installed as needed.

Water will flow directly into the bottom of the wetland from the downgradient end of the rock drain. Flow rates will be controlled at the rock drain inlet. It is assumed that no significant changes to the flow rate will be attributable to infiltration below the rock drain and wetland, evapotranspiration, or precipitation. The wetland effluent will discharge back into Pond 9.

7.2 PERFORMANCE

Before the pilot test begins, the inoculated wetland substrate will be photographed to document its initial composition, and an inoculate grab sample will be collected and analyzed for initial SRB and metals composition. At the end of pilot testing, samples of the wetland matrix will be collected, acid digested, and analyzed for total and dissolved metals concentrations to document the colonization of SRB and quantify accumulation of metals in the organic matrix.

Treatment performance will be determined by sampling water at the wetland inlet (collection drain) and outlet. Additional samples may be obtained from the monitoring ports, as needed. Monitoring parameters will include water pH, specific electrical conductance, temperature, ORP, DO, total organic carbon (TOC), biological oxygen demand (BOD), total sulfate, total

² Manure is a source of SRB, though these SRB will take longer to grow and colonize in the wetland matrix than those found in sediments.



dissolved sulfide, and total and dissolved metals. Metal removal rates will be determined as a function of residence time, which will be determined by flow rates through the rock drain inlet weir. Nominal hydraulic residence times calculated based on design assumptions will be confirmed through tracer studies conducted during pilot testing.

8.0 IMPLEMENTATION SCHEDULE

Construction of the passive treatment system is anticipated to commence during the first week of September, 2012. The rock drain matrix and wetland substrate will be inoculated at that time; bacterial colonization is expected to take approximately one month, based on previous experience. During the colonization period, metals will be adsorbed onto the organic matrix, saturating exchange sites.

The first pilot testing run is anticipated to commence in mid-October 2012; pilot testing is expected to last 15 weeks. This schedule is conditional on the ability to maintain desired flow rates into the treatment system, anaerobic conditions in the wetland, and accessibility during the winter.

The pilot testing campaign will be conducted in five three-week runs. During each test run, the influent flow rate will be set, starting at 1 gpm and increasing gradually to 10 gpm in subsequent runs. These runs will be designed to test a range of nominal hydraulic residence times, as indicated in Table 3.

Since flows and mass loading from the St. Louis Tunnel discharge have been found to vary seasonally, a second round of pilot testing is proposed for implementation during the 2013 spring/summer to identify any seasonal influences on treatment system metal removal rates and gather additional design criteria. This second round will be designed based on the findings of the first round of pilot testing conducted in the 2012 fall/winter.

Rhodamine dye tracer studies will be conducted during the 1 gpm flow rate run for the 2012 fall/winter pilot test period and during the 4 gpm flow rate run for the 2013 spring/summer pilot test period. The tracer studies are anticipated to continue for approximately 89 hours and 24 hours, respectively, based on the calculated nominal hydraulic residence times for the rock drain and constructed wetland. Tracer studies will be conducted to determine accurate residence times of the rock drain and constructed wetland.

A field study is proposed following completion of each of the 2013 spring/summer pilot test period to examine the extent of metal accumulation in the rock drain and wetland. The rock



drain and constructed wetland matrices will be sampled to determine the amount and distribution of metals in the system, the results of which will help define possible system operation and maintenance requirements.

9.0 DATA COLLECTION, REDUCTION, AND EVALUATION

For each test run, water quality parameters will be measured at the following frequencies and locations (Table 4). Flow rates, monitoring parameters, frequencies, and locations may be adjusted during the course of the pilot tests based on monitoring results, the ability to maintain anaerobic conditions in the wetland, and winter accessibility to the site.

- Influent flow rates will be measured three times per week using a calibrated flow control box installed along the channelized flow from Pond 11 to the rock drain inlet.
- 2. Water samples will be collected three times per week from the rock drain inlet, wetland outlet, and monitoring ports and analyzed for pH, specific electrical conductance, temperature, ORP, and DO using calibrated field meters.
- 3. Water samples will be collected once per week at the rock drain inlet, monitoring port near the rock drain outlet, and wetland outlet to measure total sulfate, total dissolved sulfide, and total and dissolved metals. TOC and BOD will also be analyzed at the rock drain inlet and wetland outlet.

A quality assurance/quality control program, including instrument calibration and collection of duplicate samples, will be implemented in accordance with the Sampling and Analysis Plan developed for this work (Appendix A).

In addition to obtaining field measurements and analytical data, simple rhodamine dye tracer studies will be conducted to determine accurate residence times of the rock drain and constructed wetland. Water samples will be collected periodically during the tracer studies and analyzed using a calibrated field fluorometer to measure rhodamine concentrations throughout the system.

Pilot test monitoring results will be reduced and evaluated to determine the relationship between treatment performance and residence time. This relationship will be expressed as an areal or volumetric metal removal rate and will provide a reasonable estimate of the surface area required to remove metals from the St. Louis Tunnel discharge. It is noteworthy that removal rates will depend on metal loading, which will be affected by other potential treatment systems upstream of the St. Louis Tunnel discharge.



Manganese, cadmium, and zinc mass balances across the passive treatment system (i.e., inflow load equals outflow load plus mass retained in the system) will be calculated. Metals distribution within the rock drain and wetland will be assessed to predict sludge accumulation rates and determine when rock matrix and wetland substrate will need to be flushed or replaced.

Additional parameters for developing a full-scale treatment system will be defined, including support infrastructure, water conveyance, control of water flows, and requirements to maintain optimal water temperature. Particular attention will be given to winter operation of a full-scale treatment system. Recommendations for additional treatment and/or other treatment test options will be presented, if applicable.

10.0 REPORTING

Pilot test reporting, including the results of data collection, will be submitted as technical memoranda to the U.S. EPA throughout the proposed pilot testing campaign. Four reporting periods have been identified, as described below.

- 1. Construction and Pre-Implementation: A technical memorandum will be prepared after construction of the passive treatment system to document construction activities, provide an as-built description and photographs of the system, and describe the colonization of the rock drain and constructed wetland.
- Pilot Test Run Reporting, 2012: Periodic reporting during the 2012 fall/winter round of pilot testing will summarize the results of each test run, document problems encountered and solutions adopted, identify any modifications to the proposed pilot test implementation schedule, and present preliminary analyses of monitoring results.
- 3. Pilot Test Run Reporting, 2013: Periodic reporting during the 2013 spring/ summer round of pilot testing will summarize the results of each test run, document problems encountered and solutions adopted, and present preliminary analyses of monitoring results.
- 4. Final Report: A comprehensive report will be prepared that discusses the project activities, summarizes the results of all pilot test monitoring, describes the analyses, and presents the results of removal rate, hydraulic residence time, metal accumulation rate, and sludge formation rate calculations. This final report will provide a basis for fully evaluating this passive treatment option.

Results of the limited bench-scale testing will also be submitted as technical memoranda to the U.S. EPA.



11.0 REFERENCES

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SOLUBILITY PRODUCTS: LOG K_{SP} OF SELECTED METAL SULFIDES

Rico-Argentine Mine Site - Rico Tunnels Dolores County, Colorado

Metal Sulfide	Log K _{sp}	Metal Sulfide	Log K _{sp}
Ag₂S	-50.1	FeS	-18.1
Bi₂S₃	-100.0	HgS	-52.7
CdS	-25.8	MnS	-10.5
CoS	-21.3	NiS	-19.4
CuS	-36.1	PbS	-27.5
Cu₂S	-47.7	ZnS	-24.7

Notes:

- Solubility products are general for metal sulfides at 25 degrees Celsius and are not site-specific.
 Source: Jackson, E. 1986. Hydrometallurgical Extraction and Reclamation, Ellis Horwood Ltd., Chichester, England, p. 149.



COMPOSITION OF WETLAND SUBSTRATE

Rico-Argentine Mine Site - Rico Tunnels Dolores County, Colorado

Constituent	Percent (by Volume)
Inert rock ¹	50%
Wood chips	40%
Manure	10%
Sulfur prills	0.5%
Liquid fish fertilizer	0.02%

Note:

1. Inert rock will be a mix of gravel and limestone, if limestone is readily available.



ANTICIPATED PILOT TESTING FLOW RATES AND **NOMINAL HYDRAULIC RESIDENCE TIMES**

Rico-Argentine Mine Site - Rico Tunnels Dolores County, Colorado

Flow Rate ¹ (gpm)	Rock Drain Nominal Hydraulic Residence Time ² (hours)	Constructed Wetland Nominal Hydraulic Residence Time ³ (hours)
1	27	52
2	13	26
4	6.7	13
8	3.4	6.5
10	2.7	5.2

Notes:

- 1. Flow rates will be measured and reported accurately, and residence times will be confirmed through tracer studies conducted during the 2012 fall/winter and 2013 spring/summer pilot tests.
- 2. Rock drain nominal hydraulic residence times were calculated based on the following
 - Rock drain volume is assumed to be 900 cubic feet (ft³).
 - Rock drain porosity is assumed to be 30% by volume.
 - Rock drain void volume is assumed to be 270 ft³.
 - Effective contact is assumed to be 80%.
 - Effective void volume is calculated to be 216 ft³.
- 3. Constructed wetland nominal hydraulic residence times were calculated based on the following assumptions:
 - Wetland volume is assumed to be 2,625 ft³.
 - Wetland porosity is assumed to be 20% by volume.
 - Wetland void volume is calculated to be 525 ft3.
 - Effective contact is assumed to be 80%.
 - Effective void volume is calculated to be 420 ft3.

Abbreviations: ft³ – cubic foot

gpm - gallon per minute



ANTICIPATED PILOT TEST MONITORING PROGRAM

Rico-Argentine Mine Site – Rico Tunnels Dolores County, Colorado

		Analyte (analytical method)									
	pН	Conductivity	Temperature	ORP	DO	Sulfide Dissolved	тос	BOD	Sulfate Total	Metals Total	Metals Dissolved
Monitoring Location	(meter)	(meter)	(meter)	(meter)	(meter)	(meter)	(SM 5310B)	(SM 5210B)	(EPA 300.0)	(EPA 200.8)	(EPA 200.8)
Rock Drain Inlet	3/week	3/week	3/week	3/week	3/week	1/week	1/week	1/week	1/week	1/week	1/week
Wetland Inlet	3/week	3/week	3/week	3/week	3/week	1/week	1/week	1/week	1/week	1/week	1/week
Wetland Outlet	3/week	3/week	3/week	3/week	3/week	1/week	1/week	1/week	1/week	1/week	1/week

Notes:

- 1. The analytical method "meter" indicates that the parameter will be measured using an appropriate field instrument.
- 2. The analytical method prefix "SM" refers to a laboratory standard method.
- 3. The analytical method prefix "EPA" refers to a laboratory method developed by the United States Environmental Protection Agency.
- 4. Additional monitoring may be conducted for diagnostic purposes via the perforated monitoring ports installed near the wetland inlet and outlet. Samples collected for any such monitoring will be analyzed for most of these parameters.
- 5. Monitoring parameters, frequencies, and locations may be adjusted during the course of the pilot tests based on monitoring results, the ability to maintain anaerobic conditions in the wetland, and winter accessibility to the site.
- 6. BOD samples have short laboratory holding times (analysis must be completed within 24 hours from the time the sample is collected). Due to the remoteness of the site, shipment of BOD samples and subsequent BOD analysis within the short holding time may not be possible.

Abbreviations:

BOD - biological oxygen demand

DO - dissolved oxygen

ORP - oxidation reduction potential

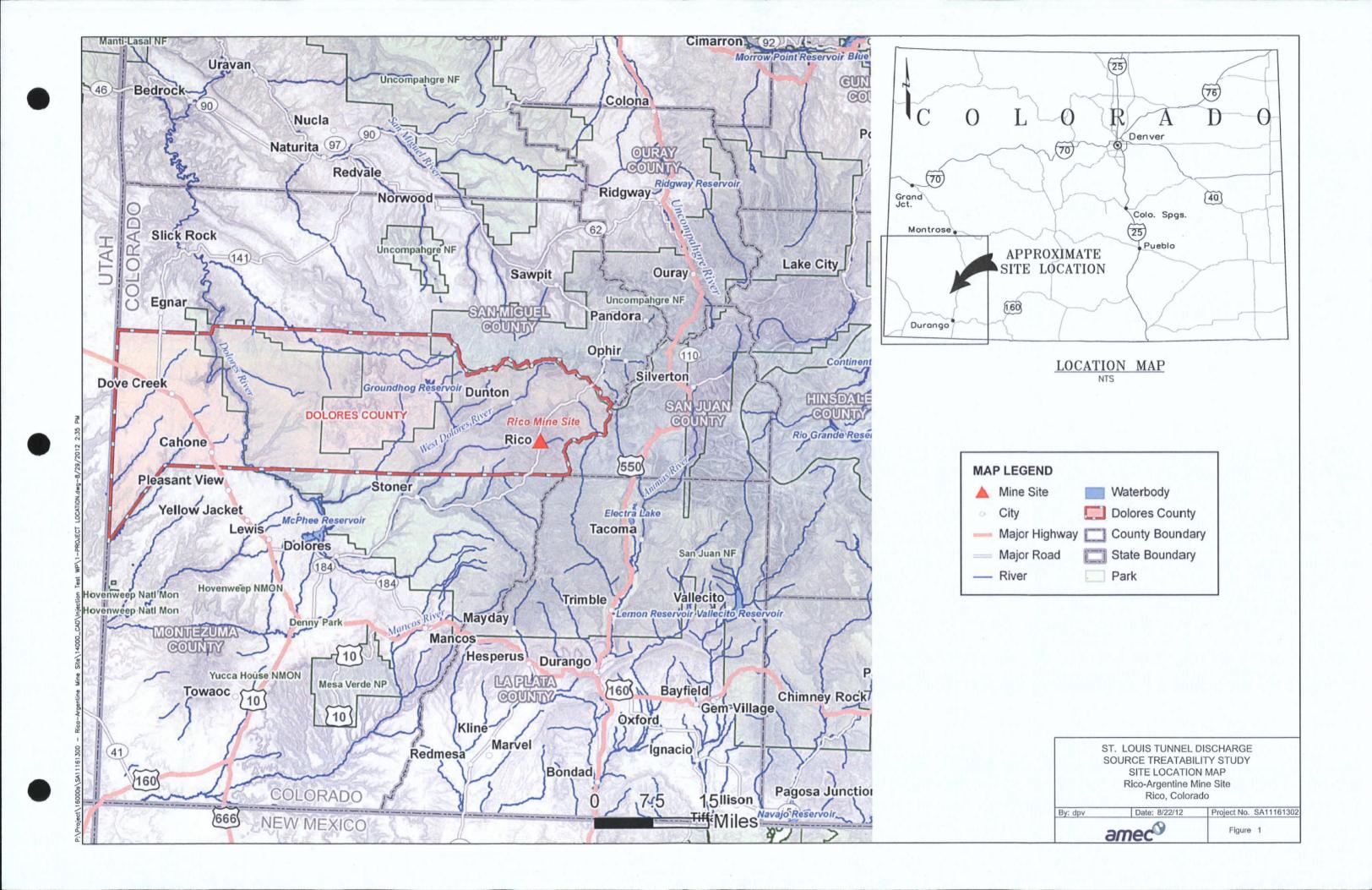
TOC - total organic carbon

1/week - samples will be collected and submitted to an analytical laboratory one time per week during each test run

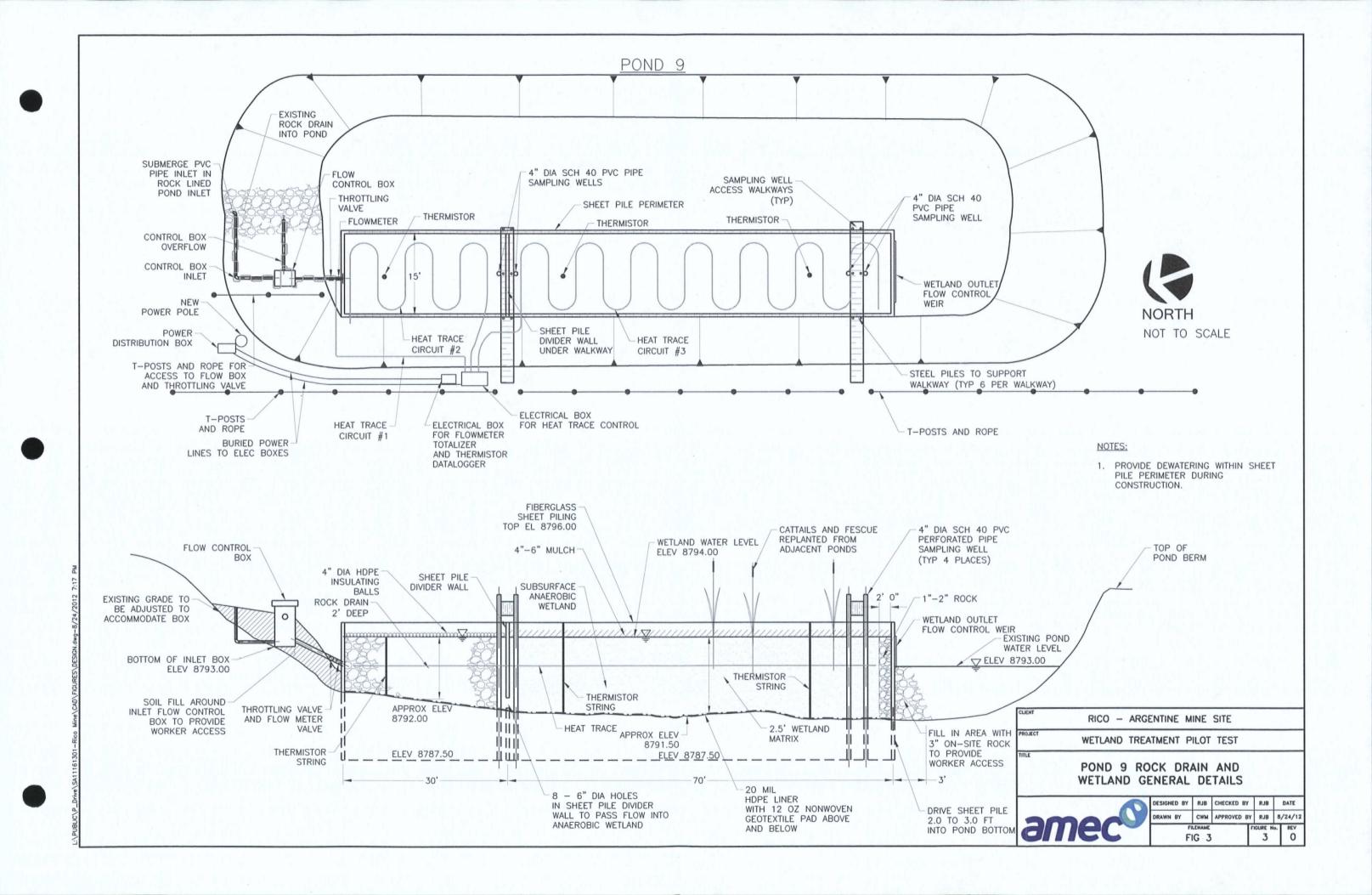
3/week - field monitoring parameters will be measured three times per week during each test run



FIGURES



ct/16000s\SA11161300 - Rico-Argentine Mine Site\14000_CAD\Injection Test WP\2_Rico Mine Site.m





APPENDIX A

SAMPLING AND ANALYSIS PLAN
ST. LOUIS TUNNEL DISCHARGE CONSTRUCTED
WETLAND PILOT SCALE TEST WORK PLAN
Rico-Argentine Mine Site – Rico Tunnels
Operable Unit OU01
Dolores County, Colorado

August 2012

Project SA11161301



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ABBREVIATIONS

AMEC AMEC Environment & Infrastructure, Inc.

Atlantic Richfield **Atlantic Richfield Company** BOD biological oxygen demand

DO dissolved oxygen DQO data quality objective Field Sampling Plan **FSP** gallon per minute gpm

Health, Safety, Security and Environment **HSSE**

mV milliVolt

ORP oxidation reduction potential

St. Louis Tunnel Discharge Constructed Wetland Pilot Scale Test pilot test

Quality Assurance Project Plan QAPP QA/QC quality assurance and quality control

Sampling and Analysis Plan SAP

site Rico-Argentine Mine Site - Rico Tunnels, Operable Unit OU01, Dolores

County, Colorado

SOP **Standard Operating Procedure** SRB

sulfate-reducing bacteria

TSEAs Task Safety Environmental Analyses

TOC total organic carbon

U.S. Environmental Protection Agency U.S. EPA

Work Plan St. Louis Tunnel Discharge Constructed Wetland Pilot Scale Test

Work Plan



APPENDIX A

SAMPLING AND ANALYSIS PLAN ST. LOUIS TUNNEL DISCHARGE CONSTRUCTED WETLAND PILOT SCALE TEST WORK PLAN

Rico-Argentine Mine Site – Rico Tunnels Operable Unit OU01 Dolores County, Colorado

1.0 INTRODUCTION

This Sampling and Analysis Plan (SAP) has been prepared by AMEC Environment & Infrastructure, Inc. (AMEC), on behalf of Atlantic Richfield Company (Atlantic Richfield), for the St. Louis Tunnel Discharge Constructed Wetland Pilot Scale Test (pilot test). This pilot test is being conducted to assess the feasibility and performance of a passive treatment system at the Rico-Argentine Mine Site (site) composed of an aerobic rock drain for manganese removal, followed in series by an anaerobic subsurface flow constructed wetland for cadmium and zinc removal. This SAP is task-specific and complements the existing site SAP (Atlantic Richfield, 2012), which was previously submitted to the U.S. Environmental Protection Agency (U.S. EPA). The existing site SAP fulfills a requirement of the Unilateral Administrative Order for Removal Action, issued by the U.S. EPA Region 8 on March 17, 2011, for the Rico-Argentine Mine Site (U.S. EPA, 2011).

1.1 PURPOSE

This task-specific SAP provides guidance for the fieldwork activities that are described in the St. Louis Tunnel Discharge Constructed Wetland Pilot Scale Test Work Plan (Work Plan; AMEC, 2012). It also ensures that the sampling and data collection activities will meet the objectives of the treatability study. This SAP outlines the field procedures, sampling and data collection activities, and analytical procedures to complete the treatability study tasks.

Analytical data and field measurements collected in accordance with this SAP will have the following primary purposes:

Evaluate key operating conditions (maintenance of aerobic conditions within the
rock drain and anaerobic conditions within the constructed wetland) as a function
of residence time and season, determined by field measured water quality
parameters, analytical analyses, and completion of tracer studies.



- Evaluate the treatment effectiveness of the St. Louis Tunnel discharge (via Pond 11) through the rock drain and constructed wetland, as measured by analysis of metals concentrations.
- Evaluate the accumulation of metals in the rock drain and constructed wetland
 and determine permeability changes in the solid matrices to calculate a mass
 balance for metal loads in the system and confirm treatment effectiveness, as
 determined by metals analysis of the rock drain matrix and wetland organic
 matrix.
- The entire data set will be analyzed to evaluate the feasibility of treating the St. Louis Tunnel discharge using a full-scale rock drain and constructed wetland treatment system.

1.2 HEALTH, SAFETY, SECURITY, AND ENVIRONMENT (HSSE) EXPECTATIONS

All sampling and analysis activities as described in this SAP will be performed in accordance with the Task Specific Health and Safety Plans prepared by Atlantic Richfield contractors. The appropriate Risk Assessment, Task Safety Environmental Analyses (TSEAs), Standard Operating Procedures (SOPs), and permits will be completed prior to initiating any work described herein.

2.0 OBJECTIVES AND SCOPE

The following subsections describe the objectives and scope of this task-specific SAP.

2.1 OBJECTIVES

The objectives of this SAP are as follows:

- Provide guidance for field, laboratory, data collection, and sample analysis
 activities so that the results will meet the objectives and tasks of the pilot test.
- Ensure that sampling and data collection activities will be comparable to and compatible with previous data collection activities.
- Provide a mechanism for planning and approving field activities.

The objectives of the pilot test are described in the Work Plan. This work is intended to support future activities at the site in order to evaluate certain treatment technologies for the purpose of supporting technology selection, alternatives evaluation, and future treatment system design. Specific data quality objectives (DQOs) for the data collection and sampling activities associated with this pilot test are described in Section 4 of this SAP.



2.2 SCOPE

This task-specific SAP has a limited scope and has been prepared to fulfill the objectives of the pilot test, to be conducted downstream of the St. Louis Tunnel discharge in Pond 9, as described in the Work Plan. This SAP includes a Field Sampling Plan (FSP), Quality Assurance Project Plan (QAPP), and SOPs that will be used for all field activities to collect samples, measure water quality parameters in the field, and generate data for evaluation of the treatability study. This SAP and its components are therefore task-specific for the pilot test and are intended to complement the existing SAP (Atlantic Richfield, 2012) and QAPP (Atlantic Richfield, 2011a) for the site.

The FSP (Section 3) provides guidance for the fieldwork that will be used to complete the tasks and objectives as defined within the Work Plan. The task-specific QAPP (Section 4) establishes the policy, organization, functional activities, and quality assurance and quality control (QA/QC) protocols needed to achieve the decision objectives. The SOPs (Attachment A-1) establish the procedures, equipment, and documentation that will be used during the pilot test field sampling, data measurement, and analytical activities.

3.0 FIELD SAMPLING PLAN

This section presents the pilot test FSP. Note that pilot test flow rates, monitoring parameters, frequencies, and locations may be adjusted during the course of the pilot tests based on monitoring results, the ability to maintain anaerobic conditions in the wetland, and winter accessibility to the site.

- 1. Colonization Period. During the colonization period (following construction and inoculation of the rock drain and wetland), system inflow will be adjusted to approximately 1 gallon per minute (gpm). Field monitoring will be conducted to assess colonization of the rock drain and wetland and determine when pilot testing can commence. The following water quality parameters will be monitored: pH, specific electrical conductance, temperature, oxidation reduction potential (ORP), and dissolved oxygen (DO). It is anticipated that pilot testing will commence when ORP is measured to be less than -100 milliVolts (mV) in the wetland.
- 2. Pre-Implementation. Prior to the commencement of pilot testing, one baseline influent water sample will be collected for laboratory analysis of metals and sulfate and field measurement of sulfide and water quality parameters (pH, specific electrical conductance, temperature, ORP, and DO). Rock used in the rock drain will be photographed and visually inspected to document colonization of manganese oxidizing bacteria. One baseline rock sample will be collected and submitted to an analytical laboratory for acid leach testing to quantify baseline metal concentrations coating the rock. Inoculated wetland organic matrix



substrate will be photographed and visually inspected to document sulfatereducing bacteria (SRB) colonization, and one sample will be submitted to an analytical laboratory to quantify baseline metals concentrations.

- 3. 2012 Fall/Winter Pilot Test. The pilot test will include introducing flows of approximately 1 gpm to 10 gpm from the Pond 11 discharge into the rock drain and constructed wetland for approximately 15 weeks during the 2012 fall/winter. During the pilot test, water samples will be collected for laboratory analysis of metals, sulfate, total organic carbon (TOC), and biological oxygen demand (BOD) and field measurement of sulfide and water quality parameters (pH, specific electrical conductance, temperature, ORP, and DO). A rhodamine dye tracer will be added to the system inflow to quantify rock drain and constructed wetland hydraulic residence times.
- 2013 Spring/Summer Pilot Test. The 2012 fall/winter pilot test and tracer study will be repeated during the 2013 spring/summer to identify any seasonal effects on water treatment.
- 5. Post-Implementation. Upon completion of the 2013 spring/summer pilot testing period, rock samples will be collected from the rock drain for visual inspection, photographed to document manganese oxidizing bacteria colonization, and submitted to an analytical laboratory for acid leach testing to quantify accumulated metal concentrations coating the rock. Wetland organic matrix substrate will be photographed to document SRB colonization and evidence of sliming/plugging and sampled and analyzed to quantify metals accumulation in the wetland organic matrix.

The primary indicators of pilot system effectiveness will be the decrease of metal concentrations in the rock drain and constructed wetland effluent. Metal removal rates will be determined as a function of residence time, which in turn will be determined by flow rates through the rock drain inlet flow control box.

3.1 SAMPLE LOCATIONS

Samples will be obtained and water quality parameters will be measured at the following locations.

- 1. Rock drain inlet (background sample) field water quality parameters, sulfide, metals, sulfate, TOC, and BOD
- 2. Rock drain monitoring port field water quality parameters, sulfide, metals, and sulfate
- Wetland outlet (final effluent sample) field water quality parameters, sulfide, metals, sulfate, TOC, and BOD
- 4. Monitoring ports inside the constructed wetland field water quality parameters



- Near the wetland inlet ("Wetland Monitoring Port #1")
- Near the wetland outlet ("Wetland Monitoring Port #2")
- · Additional monitoring ports, installed as needed

In addition, rock and organic matrix samples will be collected from 12 locations each along several transects in the rock drain and the constructed wetland to quantify accumulated metal concentrations and determine if there is uniformity or a gradient of metal accumulation throughout the system.

Table A-1 summarizes the sample locations, sampling frequency, field measurements, and analytical methods that will be utilized during the pilot test.

3.2 SAMPLING METHODS AND FREQUENCY

The following subsections describe the pilot test sampling methods and frequency, organized by phase (Table A-1). Note that pilot test flow rates, monitoring parameters, frequencies, and locations may be adjusted during the course of the pilot tests based on monitoring results, the ability to maintain anaerobic conditions in the wetland, and winter accessibility to the site.

3.2.1 Colonization Period

Water quality parameters will be monitored at Wetland Monitoring Ports #1 and #2, as described in Section 3.1, during the colonization period to determine when pilot testing can commence. Field monitoring will be conducted in accordance with existing AMEC SOPs.

3.2.2 Pre-Implementation

One baseline water sample will be collected from the rock drain inlet prior to the commencement of pilot testing to characterize influent water quality parameters. Pre-implementation rock and organic matrix sampling will be conducted following construction and colonization of the rock drain and wetland but prior to the commencement of the 2012 fall/winter pilot test, as described in Section 3.0. Sample collection will be in accordance with existing AMEC SOPs and the task-specific SOPs developed for rock drain and wetland matrix sampling and analysis (Attachment A-1). Rock and organic matrix samples will be collected from the locations identified in Section 3.1.

3.2.3 Pilot Testing

During each pilot test run, flow rates will be noted, water samples will be collected, and water quality parameters will be measured as follows:



- Influent flow rates will be measured three times per week using a calibrated flow control box installed along the channelized flow from Pond 11 to the rock drain inlet.
- 2. Water samples will be collected three times per week and analyzed for pH, specific electrical conductance, temperature, ORP, and DO using calibrated field meters.
- Water samples will be collected once per week for field measurement of total dissolved sulfide and analytical laboratory analysis of TOC, BOD, total sulfate, and total and dissolved metals.

Sample collection will be in accordance with existing AMEC SOPs.

If at any point during pilot testing an odor of rotten eggs is detected in the vicinity of the constructed wetland, a Task Safety Environmental Analysis will be performed to determine if air monitoring for hydrogen sulfide is necessary.

3.2.4 Tracer Study

A rhodamine dye tracer will be added to flow control box upstream of the rock drain inlet during the 2012 fall/winter 1-gpm pilot test run and again during the 2013 spring/summer 4-gpm pilot test run. Tracer samples will be collected for the duration of the tracer studies in order to obtain, at a minimum, 12 tracer data points (Table A-1). Sampling frequency will be adjusted as needed if flow rates change or to account for observed variations from the anticipated system hydraulic residence times. Water samples will be collected from the locations identified in Section 3.1 and measured for rhodamine using a field fluorometer.

3.2.5 Post-Implementation

Post-implementation sampling will be conducted upon completion of the 2013 spring/summer pilot testing period, as described in Section 3.0. Sample collection will be in accordance with the task-specific SOPs developed for rock drain and wetland matrix sampling and analysis (Attachment A-1). Rock and organic matrix samples will be collected from the locations identified in Section 3.1.

3.3 FIELD MEASUREMENTS

Table A-2 summarizes the parameters that will be measured in the field in accordance with existing AMEC SOPs. The following parameters will be measured in the field with calibrated field instrumentation.

Flow rate



- pH
- Specific electrical conductance
- Temperature
- ORP
- DO
- Total dissolved sulfide
- Rhodamine

3.4 LABORATORY ANALYTICAL METHODS

The following parameters will be analyzed in a commercial laboratory.

- TOC in water
- BOD in water (if holding times can be met)
- Total sulfate in water
- Total and dissolved metals in water
- Acid leachate for total metals in rock drain matrix
- Total metals analysis for wetland organic matrix

Table A-2 summarizes the laboratory analytical methods that will be used for each parameter, and the QAPP (Section 4) further describes the laboratory QA/QC requirements for these analyses. Note that BOD samples have short laboratory holding times (analysis must be completed within 24 hours from the time the sample is collected). Due to the remoteness of the site, shipment of BOD samples and subsequent BOD analysis within the short holding time may not be possible.

3.5 SAMPLE DESIGNATIONS

Unique sample designations will be used for samples collected during the pilot test. To maintain organization of data, sample identification numbers will include a sample location identifier. The sample date and time will be recorded and used to correlate the sample with the phase of the pilot test (pre-implementation, 2012 fall/winter pilot test, 2013 spring/summer pilot test, and post-implementation). Location identifiers for samples will be as follows.

Rock Drain Inlet – "RockDrainIn"



- Rock Drain Monitoring Port "RockDrainMP"
- Wetland Outlet "WetlandOut"
- Monitoring Ports "WetlandMP1", "WetlandMP2", etc.

As an example, a sample collected at 1:00 PM on September 21, 2012 from the wetland outlet would be labeled as "WetlandOut_120921_1300".

Sample containers will be labeled with self-adhesive labels, and all necessary information will be filled out using waterproof ink. At a minimum, each sample label will contain the following information.

- Project name
- Site location
- · Sample identification code
- Date and time of sample collection
- Analyses required
- Method of preservation, if applicable
- Sampler's initials

3.6 SAMPLE HANDLING

The sample handling and analysis procedures are described in SOP Number 1 – Field Documentation and Sample Handling (Attachment A-1). Examples of paperwork included in the SOP are chain-of-custody forms, sample logs, and sample labels. Table A-2 identifies the required sample volumes, sample preservation methods, types of sample containers, packing and shipping requirements, sample designation requirements for the project database, documentation requirements, and holding times.

4.0 QUALITY ASSURANCE PROJECT PLAN

Atlantic Richfield's Quality Assurance Project Plan for Surface Water Monitoring at the Rico-Argentine Mine Tunnels (Atlantic Richfield, 2011a) addresses the DQOs and QA/QC procedures for conducting environmental sampling in surface water at the site, consistent with the U.S. EPA's Quality Assurance/Quality Control Guidance for Removal Activities (U.S. EPA, 1990). For this pilot test, the sampling and analysis activities conducted by AMEC and Anderson Engineering Company, Inc. will be in general accordance with these procedures.



AMEC has developed task specific SOPs (Attachment A-1) to describe field procedures for monitoring and collecting samples for testing purposes. Table A-1 summarizes sample collection and analyses to be employed prior to, during, and upon completion of the pilot test. Field analyses during the described activities will be conducted in "real-time" and data recorded in electronic format for evaluation and decision making.

The primary laboratory for water sample analysis will be Pace Analytical Lab in Lenexa, Kansas, an environmental testing laboratory accredited through the National Environmental Laboratory Accreditation Program (Kansas NELAP Certificate No. E-101116). Additional laboratories identified to support specialized testing for tracer compounds, rock matrices, or wetland organic matrix substrate will need to meet the minimum QA/QC requirements provided in the site QAPP (Atlantic Richfield, 2011a) in order to satisfy the DQOs. Samples will be submitted to appropriate laboratories using proper chain-of-custody procedures for the respective U.S. EPA approved methodologies presented in Table A-2. The laboratory will adhere to the additional quality control requirements set forth in *Atlantic Richfield's Technical Requirements for Environmental Laboratory Services* (Atlantic Richfield, 2011b), which provides quality standards for contracted laboratories performing work for Atlantic Richfield. Laboratory results will be provided to AMEC for data verification and evaluation of the pilot test results.



5.0 REFERENCES

- AMEC, 2012, St. Louis Tunnel Discharge Constructed Wetland Pilot Scale Test Work Plan, Rico-Argentine Mine Site Rico Tunnels Operable Unit OU01, Dolores County, Colorado, August 2012.
- Atlantic Richfield, 2011a, Quality Assurance Project Plan for Surface Water Sampling, Rico-Argentine Mine Site Rico Tunnels Operable Unit OU01, Colorado, Submitted to U.S. EPA Region 8, 20 June 2011.
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- U.S. EPA, 1990, Quality Assurance/Quality Control Guidance for Removal Activities: Sampling QA/QC Plan and Data Validation Procedures, OSWER DN9360.4-01, U.S. Environmental Protection Agency, April 1990.
- U.S. EPA, 2011, Unilateral Administrative Order for Removal Action, Rico-Argentine Site, Dolores County, Colorado, Docket No., CERCLA-08-2011-0005, U.S. Environmental Protection Agency, 17 March 2011.



TABLES



TABLE A-1 FIELD SAMPLING PLAN SUMMARY WETLAND PILOT TEST SAMPLING AND ANALYSIS PLAN

Rico-Argentine Mine Site - Rico Tunnels Dolores County, Colorado

Phase	Estimated Duration (weeks)	Location	Sample Frequency	Number of Samples	Sampling Method	Analyses	Rationale
Colonization Period	4	Wetland Monitoring Port #1	1 sample per week	4	Grab	Field Measurements (1)	Monitor wetland anaerobic conditions
ODIOTIIZAUOTT GITOU	, ,	Wetland Monitoring Port #2	1 sample per week	4	Grab	Field Measurements (1)	Monitor wetland anaerobic conditions
2012 Fall/Winter		Rock Drain Inlet	1 baseline influent	1	Grab	Field Measurements (1); Lab (3)	Baseline conditions at system inlet
Pre-Implementation	, - '	Rock Drain Matrix	1 baseline matrix sample	1	Grab	Visual Inspection; Photograph; Lab (5)	Baseline conditions
1 to implementation		Wetland Organic Matrix	1 baseline matrix sample	1	Grab	Visual Inspection; Photograph; Lab (6)	Baseline conditions
		Rock Drain Inlet	3 samples per week	9	Grab	Field Measurements (1)	Assess operational parameters
	i	Rock Drain Inlet	1 sample per week	3	Grab	Lab (3) and (4)	Monitor water quality impacts
		Rock Drain Monitoring Port	3 samples per week	9	Grab	Field Measurements (1)	Assess operational parameters
2012 Fall/Winter	1	Hock Drain Monitoring Port	1 sample per week	3	Grab	Lab (3)	Monitor water quality impacts
1 gpm Test Run	· 3	Wetland Monitoring Port #1	3 samples per week	9	Grab	Field Measurements (1)	Assess operational parameters
		Wetland Monitoring Port #2	3 samples per week	9	Grab	Field Measurements (1)	Assess operational parameters
		Market de Contra	3 samples per week	9	Grab	Field Measurements (1)	Assess operational parameters
	1	Wetland Outlet	1 sample per week	3	Grab	Lab (3) and (4)	Monitor water quality impacts
			1 sample per 0.5 hour, start-up	9	Grab	Field Measurements (2)	Start-up time hour 0 to hour 4
	1	Rock Drain Inlet	1 sample per hour	90	Autosample	Field Measurements (2)	Hour 0 to hour 89
2012 Fall/Winter	0.6	Rock Drain Monitoring Port	1 sample per hour	90	Autosample	Field Measurements (2)	Hour 0 to hour 89
1 gpm Tracer Study	(89 hours)	Wetland Monitoring Port #1	1 sample per hour	90	Autosample	Field Measurements (2)	Hour 0 to hour 89
		Wetland Outlet	1 sample per hour	90	Autosample	Field Measurements (2)	Hour 0 to hour 89
			3 samples per week	9	Grab	Field Measurements (1)	Assess operational parameters
		Rock Drain Inlet	1 sample per week	3	Grab	Lab (3) and (4)	Monitor water quality impacts
	3		3 samples per week	9	Grab	Field Measurements (1)	Assess operational parameters
2012 Fall/Winter		Rock Drain Monitoring Port	1 sample per week	3	Grab	Lab (3)	Monitor water quality impacts
2 gpm Test Run		Wetland Monitoring Port #1	3 samples per week	9	Grab	Field Measurements (1)	Assess operational parameters
- -		Wetland Monitoring Port #2	3 samples per week	9	Grab	Field Measurements (1)	Assess operational parameters
		,	3 samples per week	9	Grab	Field Measurements (1)	Assess operational parameters
		Wetland Outlet	1 sample per week	3	Grab	Lab (3) and (4)	Monitor water quality impacts
			3 samples per week	9	Grab	Field Measurements (1)	Assess operational parameters
		Rock Drain Inlet	1 sample per week	3	Grab	Lab (3) and (4)	Monitor water quality impacts
			3 samples per week	9	Grab	Field Measurements (1)	Assess operational parameters
2012 Fall/Winter	_	Rock Drain Monitoring Port	1 sample per week	3	Grab	Lab (3)	Monitor water quality impacts
4 gpm Test Run	3	Wetland Monitoring Port #1	3 samples per week	9	Grab	Field Measurements (1)	Assess operational parameters
•		Wetland Monitoring Port #2	3 samples per week	9	Grab	Field Measurements (1)	Assess operational parameters
			3 samples per week	9	Grab	Field Measurements (1)	Assess operational parameters
		Wetland Outlet	1 sample per week	3	Grab	Lab (3) and (4)	Monitor water quality impacts
			3 samples per week	9	Grab	Field Measurements (1)	Assess operational parameters
		Rock Drain Inlet	1 sample per week	3	Grab	Lab (3) and (4)	Monitor water quality impacts
			3 samples per week	9	Grab	Field Measurements (1)	Assess operational parameters
2012 Fall/Winter		Rock Drain Monitoring Port	1 sample per week	3	Grab	Lab (3)	Monitor water quality impacts
8 gpm Test Run	3	Wetland Monitoring Port #1	3 samples per week	9	Grab	Field Measurements (1)	Assess operational parameters
√r		Wetland Monitoring Port #2	3 samples per week	9	Grab	Field Measurements (1)	Assess operational parameters
			3 samples per week	9	Grab	Field Measurements (1)	Assess operational parameters
	1	Wetland Outlet	1 sample per week	3	Grab	Lab (3) and (4)	Monitor water quality impacts



TABLE A-1 FIELD SAMPLING PLAN SUMMARY WETLAND PILOT TEST SAMPLING AND ANALYSIS PLAN

Rico-Argentine Mine Site - Rico Tunnels Dolores County, Colorado

Phase	Estimated Duration (weeks)	Location.	Sample Frequency	Number of Samples	Sampling Method	Analyses	Rationale
	}	Rock Drain Inlet	3 samples per week	99	Grab	Field Measurements (1)	Assess operational parameters
			1 sample per week	3	Grab	Lab (3) and (4)	Monitor water quality impacts
		Rock Drain Monitoring Port	3 samples per week	9	Grab	Field Measurements (1)	Assess operational parameters
2012 Fall/Winter	3		1 sample per week	3	Grab	Lab (3)	Monitor water quality impacts
10 gpm Test Run	"	Wetland Monitoring Port #1	3 samples per week	9	Grab	Field Measurements (1)	Assess operational parameters
		Wetland Monitoring Port #2	3 samples per week	9	Grab	Field Measurements (1)	Assess operational parameters
		Wetland Outlet	3 samples per week	9	Grab	Field Measurements (1)	Assess operational parameters
		wetiand Odilet	1 sample per week	3	Grab	Lab (3) and (4)	Monitor water quality impacts
		Rock Drain Inlet	3 samples per week	9	Grab	Field Measurements (1)	Assess operational parameters
		Rock Drain inlet	1 sample per week	3	Grab	Lab (3) and (4)	Monitor water quality impacts
		Rock Drain Monitoring Port	3 samples per week	9	Grab	Field Measurements (1)	Assess operational parameters
2013 Spring/Summer	3	Hock Drain Monitoring Port	1 sample per week	3	Grab	Lab (3)	Monitor water quality impacts
1 gpm Test Run	l 3	Wetland Monitoring Port #1	3 samples per week	9 .	Grab	Field Measurements (1)	Assess operational parameters
		Wetland Monitoring Port #2	3 samples per week	9	Grab	Field Measurements (1)	Assess operational parameters
		Manad Code	3 samples per week	9	Grab	Field Measurements (1)	Assess operational parameters
		Wetland Outlet	1 sample per week	3	Grab	Lab (3) and (4)	Monitor water quality impacts
		Rock Drain Inlet	3 samples per week	9	Grab	Field Measurements (1)	Assess operational parameters
		Rock Drain Inlet	1 sample per week	3	Grab	Lab (3) and (4)	Monitor water quality impacts
		Deal Designation New York	. 3 samples per week	9	Grab	Field Measurements (1)	Assess operational parameters
2013 Spring/Summer		Rock Drain Monitoring Port	1 sample per week	3	Grab	Lab (3)	Monitor water quality impacts
2 gpm Test Run	3	Wetland Monitoring Port #1	3 samples per week	. 9	Grab	Field Measurements (1)	Assess operational parameters
•		Wetland Monitoring Port #2	3 samples per week	9	Grab	Field Measurements (1)	Assess operational parameters
			3 samples per week	9	Grab	Field Measurements (1)	Assess operational parameters
		Wetland Outlet	1 sample per week	3	Grab	Lab (3) and (4)	Monitor water quality impacts
		<u> </u>	3 samples per week	9	Grab	Field Measurements (1)	Assess operational parameters
		Rock Drain Inlet	1 sample per week	3	Grab	Lab (3) and (4)	Monitor water quality impacts
			3 samples per week	9	Grab	Field Measurements (1)	Assess operational parameters
2013 Spring/Summer		Rock Drain Monitoring Port	1 sample per week	3	Grab	Lab (3)	Monitor water quality impacts
4 gpm Test Run	3	Wetland Monitoring Port #1	3 samples per week	9	Grab	Field Measurements (1)	Assess operational parameters
		Wetland Monitoring Port #2	3 samples per week	9	Grab	Field Measurements (1)	Assess operational parameters
			3.samples per week	9	Grab	Field Measurements (1)	Assess operational parameters
		Wetland Outlet	1 sample per week	3	Grab	Lab (3) and (4)	Monitor water quality impacts:
	i .	Bask Busin Inter	1 sample per 0.5 hour, start-up	. 9	Grab	Field Measurements (2)	Start-up time hour 0 to hour 4
2040 0 - 1-1-10	l	Rock Drain Inlet	1 sample per hour	25	Autosample	Field Measurements (2)	Hour 0 to hour 24
2013 Spring/Summer	0.3	Rock Drain Monitoring Port	1 sample per hour	25	Autosample	Field Measurements (2)	Hour 0 to hour 24
4 gpm Tracer Study	(24 hours)	Wetland Monitoring Port #1	1 sample per hour	25	Autosample	Field Measurements (2)	Hour 0 to hour 24
	i	Wetland Outlet	1 sample per hour	25	Autosample	Field Measurements (2)	Hour 0 to hour 24



TABLE A-1 FIELD SAMPLING PLAN SUMMARY WETLAND PILOT TEST SAMPLING AND ANALYSIS PLAN

Rico-Argentine Mine Site - Rico Tunnels Dolores County, Colorado

Phase	Estimated Duration (weeks)	Location	Sample Frequency	Number of Samples	Sampling Method	Analyses	Rationale
	1	Director Description Indian	3 samples per week	9	Grab	Field Measurements (1)	Assess operational parameters
		Rock Drain Inlet	1 sample per week	3	Grab	Lab (3) and (4)	Monitor water quality impacts
		Rock Drain Monitoring Port	3 samples per week	9	Grab	Field Measurements (1)	Assess operational parameters
2013 Spring/Summer	3	Hock Drain Worldoning For	1 sample per week	3	Grab	Lab (3)	Monitor water quality impacts
8 gpm Test Run	"	Wetland Monitoring Port #1	3 samples per week	9	Grab	Field Measurements (1)	Assess operational parameters
		Wetland Monitoring Port #2	3 samples per week	9	Grab	Field Measurements (1)	Assess operational parameters
		Wetland Outlet	3 samples per week	. 9	Grab	Field Measurements (1)	Assess operational parameters
	l	Welland Obliet	1 sample per week	3	Grab	Lab (3) and (4)	Monitor water quality impacts
		Rock Drain Inlet	3 samples per week	9	Grab	Field Measurements (1)	Assess operational parameters
	1	Hock Drain inlet	1 sample per week	3	Grab	Lab (3) and (4)	Monitor water quality impacts
		Rock Drain Monitoring Port	3 samples per week	9	Grab	Field Measurements (1)	Assess operational parameters
2013 Spring/Summer	3	Nock Drain Worldoning Fort	1 sample per week	3	Grab	Lab (3)	Monitor water quality impacts
10 gpm Test Run	°	Wetland Monitoring Port #1	3 samples per week	9	Grab	Field Measurements (1)	Assess operational parameters
		Wetland Monitoring Port #2	3 samples per week	9	Grab	Field Measurements (1)	Assess operational parameters
		Wetland Outlet	3 samples per week	9	Grab	Field Measurements (1)	Assess operational parameters
		AAAnaug Ognet	1 sample per week	3	Grab	Lab (3) and (4)	Monitor water quality impacts
2013 Spring/Summer		Rock Drain Matrix	12 rock samples	12	Grab	Visual Inspection; Photograph; Lab (5)	Post-pilot test conditions
Post-Implementation		Wetland Organic Matrix	12 organic matrix samples	12	Grab	Visual Inspection; Photograph; Lab (6)	Post-pilot test conditions

Notes/Abbreviations:

- (1) Field measurements consist of flow, pH, temperature, specific electrical conductance, oxidation reduction potential, and dissolved oxygen using calibrated instrumentation.
- (2) Field measurements will be conducted using a calibrated field fluorometer.
- (3) Lab Analyses: total sulfate, total dissolved sulfide, and total and dissolved metals using methods shown in Table A-2.
- (4) Lab Analyses: total organic carbon and biological oxygen demand (BOD) using methods shown in Table A-2. Note that BOD samples have short laboratory holding times (analysis must be completed within 24 hours from the time the sample is collected). Due to the remoteness of the site, shipment of BOD samples and subsequent BOD analysis within the short holding time may not be possible.
- (5) Lab Analyses: rock drain matrix acid leach test for total and dissolved metals using methods shown in Table A-2.
- (6) Lab Analyses: wetland organic matrix sample analysis for total metals using methods shown in Table A-2.
- (7) Pilot test flow rates, monitoring parameters, frequencies, and locations may be adjusted during the course of the pilot tests based on monitoring results, the ability to maintain anaerobic conditions in the wetland, and winter accessibility to the site.

gpm - gallons per minute



TABLE A-2 METHODS, HOLDING TIMES, AND PRESERVATION REQUIREMENTS WETLAND PILOT TEST SAMPLING AND ANALYSIS PLAN

Rico-Argentine Mine Site – Rico Tunnels Dolores County, Colorado

Parameter	Method Reference	Container	Suggested Volume ¹	Preservation ²	Estimated Detection Limit	Maximum Holding Time
		La	aboratory Analyses	· ·		
Total Organic Carbon	SM 5310B	Р	250 mL	HCI to pH<2	0.5 mg/L	28 days
Biological Oxygen Demand ³	SM 5210B	P	1 L	None	4.0 mg/L	24 hours
Total Sulfate	EPA 300.0	Р	100 mL	None	1.0 mg/L	28 days
Total and Dissolved Metals ⁴	EPA 200.8/245.1	Р	500 mL	HNO₃ to pH<2; Field filtered for dissolved metals	0.02 - 25 μg/L	6 months
	Field SOP 6	PB	200 g	None	N/A	6 months
Rock Drain Acid Leach Test for Total Metals ⁵	Inductively Coupled Plasma	Р	500 mL	Leachate prepared for total metals	5 - 500 μg/L	6 months
	Field SOP 7	PB	200 g	None	N/A	N/A
Wetland Matrix Sample Analysis for Total Metals ⁵	Inductively Coupled Plasma	P	100 g	Digest prepared For total metals	0.05 – 50 mg/Kg	6 months
		F	ield Measurements	}		
Flow Rate	Flow Meter	N/A	N/A	N/A	0.1 cfs	N/A
рН					0.1 unit	15 minutes
Specific Electrical Conductance					0.1 μS/cm	15 minutes
Temperature					0.1 °C	15 minutes
Oxidation Reduction Potential	Field SOP 3	Р	100 mL	None	0.1 mV	15 minutes
Dissolved Oxygen					0.2 mg/L	15 minutes
Total ⁶ Dissolved Sulfide					0.01 mg/L	15 minutes
Rhodamine Dye					0.4 μg/L	15 minutes



TABLE A-2 METHODS, HOLDING TIMES, AND PRESERVATION REQUIREMENTS WETLAND PILOT TEST SAMPLING AND ANALYSIS PLAN

Rico-Argentine Mine Site – Rico Tunnels Dolores County, Colorado

Notes:

- 1 Additional volume may be provided for laboratory quality control samples (e.g., matrix spike, laboratory duplicate).
- 2 Samples should be stored at a temperature ranging from 0 ℃ to 6 ℃ or analyzed immediately.
- 3 Biological oxygen demand (BOD) samples have short laboratory holding times (analysis must be completed within 24 hours from the time the sample is collected). Due to the remoteness of the site, shipment of BOD samples and subsequent BOD analysis within the short holding time may not be possible.
- 4 Metals: Al, Sb, As, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mg, Mn, Mo, Ni, K, Se, Ag, Na, Tl, V, Zn (EPA 200.8) and Hg (EPA 245.1)
- 5 Metals: Al, Sb, As, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mg, Mn, Hg, Mo, Ni, K, Se, Ag, Na, Tl, V, and Zn
- 6 "Total" in this analysis refers to the total of HS and H2S (unspeciated) in dissolved form.
- 7 Pilot test flow rates, monitoring parameters, frequencies, and locations may be adjusted during the course of the pilot tests based on monitoring results, the ability to maintain anaerobic conditions in the wetland, and winter accessibility to the site.

Abbreviations:

BOD - biological oxygen demand cfs - cubic feet per second EPA - United States Environmental Protection Agency q - gram HNO₃ - nitric acid mg/Kg - milligram per kilogram mg/L - milligram per liter mV - milliVolt μα/L - microgram per liter μS/cm - micro Siemen per centimeter N/A - not applicable P - polypropylene bottle PB - sealable plastic bag SM - standard method SOP - Standard Operating Procedure °C – degree Celsius



ATTACHMENT A-1

Standard Operating Procedures



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1.0 - FIELD DOCUMENTATION AND SAMPLE HANDLING

Purpose and Scope: The purpose of this document is to present procedures for field

documentation and sample handling. It includes a description of how to fill out a Daily Field Record (DFR), Sample Control Log, and Chain-of-Custody (COC). It also describes procedures for sample labeling,

handling, preservation, packaging, and shipping.

Equipment: The following equipment will be needed depending on specific task and

will be used, as appropriate, when packing or shipping samples:

Sample Bottles

Sample Labels

Custody Seals

Fine Tipped Permanent Markers

Nitrile gloves or other appropriate gloves

Sealable storage bags

• Bubble wrap or appropriate packing materials

Blue ice or double bagged ice

Coolers suitable for sample shipment and holding ice

Strapping/packaging tape and shipping labels, if needed

Camera with spare memory chip and batteries

Documentation:

DFR (attached)

Sample Control Log (attached)

COC Document (attached) or laboratory equivalent

Sampling Records Maps/plot plan

Camera

Photograph Log (attached)

This Standard Operating Procedure (SOP) is to be used in conjunction with the Sampling and Analysis Plans (SAPs).

1.1 FIELD AND SAMPLE DOCUMENTATION

Documentation of the conditions and procedures used to collect, treat, and handle samples and field data is one of the most important aspects of any sampling or monitoring program. Proper documentation provides sources to determine the integrity and applicability of the data. Carefully document all field activities in a field logbook or on data sheets. Field logbooks shall be bound with consecutively numbered pages and shall be written in with permanent black ink. All field logbooks will be dedicated to the Rico-Argentine Project. At the end of each field season, the original field log books and all original data sheets will be kept in the AMEC office,

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located in Rancho Cordova. Field activities shall be recorded in sufficient detail so that field activities can later be reconstructed from the notes. Any changes to the notes in the field logbook shall be made by drawing a single line through the incorrect material and initialing and dating the mark-out.

1.1.1 Daily Field Record (DFR)

Documentation of observations and data acquired in the field provide information on sample acquisition, field conditions at the time of sampling, and a permanent record of field activities. Record field observations and data collected during the investigation with waterproof ink on DFR sheets (Attached). A new DFR should be completed for each day or when a separate phase of work is initiated.

The DFRs will include the following information, as appropriate.

- Project and Task Number
- Project Name
- Location of sample (if samples are collected)
- Date
- Time
- Field Activity
- Weather Conditions
- Personnel Onsite, Company Name, and Time Onsite
- Personal Safety Checklist
- Description of Work Performed
- Description of Waste Generated

Information written within the area delineated "Description of Work Performed" should include the following:

- Sample identification number(s)
- Time of sample
- Description of sample
- Number and volume of samples



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- Field observations
- List other associated paperwork related to the activity (e.g., boring log, sample control log, maps, etc.)
- Decontamination procedures

Photographs should be taken of pertinent activities that occur during the investigation. These should include capturing images that clearly demonstrate that the goals of the project are being met. They should also be taken of any changes in procedures or unexpected findings that occur in the field. Items of scale should be included in the view of the photograph (i.e., ruler, clipboard, etc.). A running log of the photographs with a description of each photograph should be included on a photo log attached to the DFR. All photos should include the following information on the photo log: ID number generated by the camera, date the photo was taken, initials of the photographer, location of the photo, direction of view and any additional comments or descriptions.

Strike out changes or deletions in the field book or on the data sheets with a single strike mark and be sure that the original information remains legible. Each page should be completely filled without any blank lines, if necessary write "Not Applicable" or "NA" on blank lines. The field logbook or field data sheets should be signed daily by the author of the entries.

1.1.2 Sample Control Log

If samples are collected during the field investigation, a sample control log must be filled out documenting the sample location, study area, sample matrix, sample ID, sample date, sample time, sample collector, sample depth, sample type, code (whether the sample is a normal environmental sample or which type of quality assurance/quality control [QA/QC] sample it is), additional notes (i.e. sample turnaround time, COC remarks, details about the sample or analysis, etc.), which laboratory the samples were sent to and the date they were shipped.

1.1.3 Chain of Custody (COC)

During sampling activities, a "paper trail" of sample custody must be maintained from the time the samples are collected until laboratory data are issued. Information on the custody, transfer, handling, and shipping of samples should be recorded by the sampling personnel on an Atlantic Richfield COC form. If an project or task-specific COC form is not available (i.e., with specific analytes and analytical methods listed), an equivalent form provided by the destination



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laboratory can be used instead. A COC form will be completed for each set of samples collected daily. At a minimum, every COC will contain the following information:

- Sampling Personnel's name and signature
- Project name
- Date and time of collection
- Sample identification number and matrix
- Analyses requested
- Number of containers and any preservative used
- · Signature of persons relinquishing custody, dates, and times
- Signature of persons accepting custody, dates, and times
- Method of shipment
- Shipping papers/waybill identification number (as appropriate)

Atlantic Richfield sponsors the Laboratory Management Program (LaMP). The LaMP consists of a network of approved contract laboratories that supply analytical testing services for Atlantic Richfield's environmental and remediation programs. The LaMP was implemented to ensure that the analytical testing and services needs of Atlantic Richfield Company are consistently met on environmental/remediation projects. The LaMP provides and assures sources of high quality analytical data for Atlantic Richfield that are legally defensible and minimizes the total cost of ownership. COCs for samples shipped to an Atlantic Richfield contract laboratory will contain the following information:

- Name of the lead regulatory agency
- Name and contact information of the environmental business manager
- · Name and contact information of the consultant and Project Manager
- Enfos proposal number and the stage and activity level of the project
- Level of data package requested



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An example COC is provided as an attachment and should be strictly followed as it is important that COCs are completed with consistent information. A copy of each COC form will be retained in the project files.

1.1.4 Sampling Records

Sampling records have been customized for each type of sampling (groundwater from a well, grab groundwater from a boring, surface water, storm water and storm sediment). The associated sampling record should be filled out during the sampling process. Pertinent information varies with each type of sampling, but at a minimum, the following information should be filled out for each sample:

- Sample identification number(s)
- Time of sample
- Results of any field measurements, such as depth to water, pH, temperature, specific electrical conductivity, dissolved oxygen, turbidity, discharge, etc
- Any QA/QC samples that were collected
- Field observations, such as color, odor or texture of the sample, etc.
- Method of sampling
- Name and signature of sampler

1.2 SAMPLE LABELING

After sample collection, the samples will be labeled with self-adhesive labels with all necessary information added using waterproof ink. Make sure the labels are completed so that the information is legible and consistent. At a minimum, each sample label will contain the following information:

- Project name
- Study Area or Task
- Sample identification code
- Date (mmddyy) and military time (tt:tt) of sample collection
- Analyses required
- Method of preservation, if used
- Sampler's initials



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The information on the sample label shall match the COC.

Each sample, including QA/QC samples, will be assigned a unique identification code according to sample location, date, and depth (if applicable). For example, if a sample is collected from the 517 Shaft at a depth of 450 feet below the shaft collar on August 20, 2012, the sample ID will be "517Shaft450_120820".

Field blanks and duplicates shall be labeled so that the sample location is not identified to the lab. For example, if a duplication sample is collected from the 517 Shaft on August 20, 2012, the sample ID will be "Dup_120820". The identity of field QC samples will be traceable through the sample control log.

1.3 SAMPLE HANDLING

General sample handling procedures shall include the following:

- Always make field measurements on a separate sub-sample, not on the sample that is sent to the laboratory for analysis. Discard the sub-sample after the measurements have been made.
- Do not use containers that have been used in the laboratory to store concentrated reagents or have been previously used as sample containers. Use only new containers that are certified clean by the manufacturer or laboratory for sample collection.
- For water samples, do not allow the inner portion of sample containers and caps to come into contact with bare hands, gloves, tubing or other objects.
- Keep sample containers in a clean environment away from dust, dirt, and fumes. Field personnel shall wear disposable nitrile gloves when collecting water samples. Gloves must be changed out between each water sample collected.
- Do not let any samples, including water, vegetation, or invertebrate samples, stand in the sun. Store all samples in coolers with blue or double bagged ice;
- COC procedures will be strictly adhered to during sample collection, transportation, and laboratory handling to assure the identity of the samples. Improper sample and data handling and inadequate COC procedures affect the credibility and acceptability of analytical results, regardless of their accuracy or precision. COC documentation will document processing of the sample from the time of collection to the time of analysis.



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If overnight storage of collected water samples is required prior to shipment to a laboratory, the samples will be stored in accordance to procedures described in Section 1.6.

1.4 SAMPLE PRESERVATION

Sample preservation will depend on the analytical method to be performed and the sample matrix. Preservation methods and preservatives for each analytical method and matrix will be presented in the associated SAP. The planned sample preservation activities, sample container size and type, and analytical methods should be confirmed with the laboratory well in advance of collecting samples.

For all water samples, the laboratory will supply clean, unused, and pre-preserved sample containers as appropriate. If containers are preserved, the type of preservative should be clearly labeled on each bottle. Do not rinse out sample containers. The preservative will be documented on the sample label and COC. Soil samples collected in non-laboratory certified clean containers (e.g., via split spoon, direct push or drive method), will be decontaminated prior to use in accordance to procedures described in SOP 04, Equipment Decontamination.

1.5 SAMPLE PACKAGING AND SHIPPING

If samples are required by the laboratory to be chilled, they will be stored during the day in ice-cooled containers.

Samples collected during the morning may be temporarily stored in a refrigerator (if available) until shipment in the afternoon. All samples stored in the coolers or the refrigerator will be documented on the sample control log. When samples are being packaged for shipment, the procedures listed below will be followed.

- Field personnel will visually screen each sample in the cooler for loose surface contamination, and confirm that each sample is listed on the sample control log and the COC.
- 2. Samples will be packed with abundant packaging material to minimize the potential for damage during shipment. If samples need to be chilled, they will be double-bagged in sealable plastic bags and immediately placed on ice in an insulated cooler. Insulated coolers will be provided by the contract laboratories. Sample containers will be placed right side up in a cooler with double bagged ice for delivery to the laboratory.



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- 3. The completed COC will be scanned and emailed to the lab to inform them about the sample(s) they will be receiving. The scans will be saved for project records. Then, the COC will be signed and placed in a plastic sealable storage bag which will be taped to the inside cover of the cooler. The COC form will be shipped with the cooler to confirm transfer; the carrier waybill number will be recorded on the original COC. Commercial carriers are not required to sign the COCs. However, we do need to sign over custody to the courier (if using a courier to deliver the samples to a commercial carrier) and have the courier sign over custody for the approximate time he will relinquish the samples. The lab will sign for "Accepted" when they open the cooler.
- 4. If samples are to be transported overnight via Federal Express or United Parcel Service, all ice must be double bagged to prevent leakage. The lid of the cooler must be taped shut with custody seals. The cooler will then be taped shut using clear shipping tape. Failure to seal all potential leaks may result in rejection of delivery by the courier. If samples are shipped on a Friday then Saturday delivery stickers must be attached to the coolers on all four sides as well as the top. Make sure to check the overnight delivery space on the shipping papers. Affix the label on the top or side of the cooler.
- 5. Samples will typically be shipped to the laboratory daily. Copies of the completed COC will be kept in the field office by the field manager.
- Sample shipment will be scheduled to prevent exceeding any required holding
 period. Failure to conduct analyses within the required holding times may potentially
 require the qualification of associated analytical results and will prompt appropriate
 corrective and preventive action measures.

1.6 OVERNIGHT STORAGE

If the hold time allows, samples may be stored overnight as long as they are properly packaged, labeled, placed in a secure location. If chemical analysis is to be performed on the sample, it must be stored at no more than 4°C or 39°F, but above freezing. Samples will be kept in a cooler or refrigerator locked in a secure location and shipped the following day. When placing samples into the refrigerator, make sure it is plugged in and turned on and set at the appropriate temperature. Samples should not be kept for more than a week. If samples are kept overnight, chain of custody procedures must still be followed.

1.7 REVISION LOG

Revision	Author	Description of Change (Section number)	Date
Number			



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ATTACHMENTS

- Daily Field Record (DFR)
- Sample Control Log
- Atlantic Richfield Chain-of-Custody (COC) Record
- Photograph Log



DAILY FII	ELD RECORD)								
Project and Tas	· · · · · · · · · · · · · · · · · · ·			Date:						
Project Name:				Field Activity:						
Location:				Weather:						
PERSONNEL:	Name	;		Company			Time In	Time Out		
	_									
· · · · · · · · · · · · · · · · · · ·										
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	PERS	SONA	L SAFETY C	CHECKLIST						
Safety-t	oed Boots		Hard Hat			Radio				
Nitrile/L	eather Gloves		Safety Gla	Blasses Ear Plugs						
DRUM I.D. DESCRIPTION OF CONT			CONTENT	TS AND QUANITY LOCATION				ON		
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TIME			DESCRIPTI	ON OF WORK PE	RFORM	ED				
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Page 1 of ____



DAILY FIELD RECORD (continued)								
Project and Tas			Date:					
TIME		DESCRIPTION OF WORK PERFORMED						
				- 				
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Page	of	F



SAMPLE CONTROL LOG

Project Name:	Task Name:	
Project & Task No.:	Week of:	Crew:
•		

Sample Location	Sample Matrix	Sample ID	Sampling Date	Sample Time	Sample Collector Initials	Sample Depth (feet bgs)	Sample Type ¹ Code ²	Additional Notes ³	Lab	Date Sent to Lab
-										
								-		
			•							
							·			

^{1.} Sample Types include: Grab, Composite, Incremental, or Autosampler

^{2.} Code includes: Normal Environmental (NE), Field Duplicate (FD), Field Blank (FB), Equipment Blank (EB), and Matrix Spike/Matrix Spike Duplicate (MS/MSD)

^{3.} Include notes such as: turnaround time, sample location details, handling notes, Chain-of-Custody remarks, etc.





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C	OMPANY A BP affiliated company	BP/ARC Pro	-											•	-				aa/yy Imber	_					KUSN IAI:	Yes	NO
ab Na				BP/	ARC	Facili	ty Ad	dress	:										Consu	tant/Co	ontra	ctor:					
ab Ad				City	, Stat	e, ZIF	Coc	de:											Consu	tant/Co	ontra	ctor F	rojec	t No:			
ab PN	A:			Lea	d Reg	gulato	ry Aç	gency	:										Addres	s:							
.ab Ph	one:			Cali	fornia	Glob	al ID	No.:											Consu	tant/Co	ontra	ctor P	M:				
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Sample Collection and Data Collection Techniques

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2.0 - SAMPLE COLLECTION TECHNIQUES AND DATA COLLECTION STRATEGIES

Purpose and Scope: The purpose of this document is to describe general sampling

techniques and data collection strategies.

Equipment: Nitrile gloves or other appropriate gloves

Measuring Wheel or Tape Measure

Flag markers

Hand-Held Global Positioning System (GPS) device:

Camera Marking flags Marking paint

Documentation:

Daily Field Record (DFR)

Photo Log Maps

This Standard Operating Procedure (SOP) is to be used in conjunction with a Sampling and Analysis Plan (SAP) and applicable work plans. Specific sample techniques, strategies, locations and frequency will be presented in the work plans. However, in the event that the work plans require that sample collection techniques and data collection strategies must be determined in the field (e.g. pre-investigation planning, mapping, waste sampling), the procedures within this SOP should be followed.

2.1 SAMPLE COLLECTION TECHNIQUES

Three basic types of sample collection techniques will be used: Grab and Composite Samples. These techniques are described below:

- A grab sample is defined as a discrete sample representative of a specific location at
 a given point in time. The sample is collected all at once at one particular point in the
 sample medium. The representativeness of such samples is defined by the nature of
 the materials being sampled. In general, as sources vary over time and distance, the
 representativeness of grab samples will decrease.
- A composite sample is a non-discrete sample composed of more than one sample
 collected at various sampling locations and/or different points in time. Analysis of
 this type of sample produces an average value and can in certain instances be used
 as an alternative to analyzing a number of individual grab samples and calculating an
 average value. It should be noted, however, that compositing can mask problems by
 diluting isolated concentrations of some hazardous compounds below detection
 limits.

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 Incremental sampling (IS) is a structured composite sampling protocol that reduces sampling error associated with compositional and distributional heterogeneity of the analyte of interest in soil or sediments. The IS protocol consists of defining sampling or decision units, collecting a minimum of 30 individual soil samples from randomly selected locations within each unit, and submitting the samples to the laboratory for processing (drying, compositing, sieving, and sub-sampling) in a specified manner prior to laboratory analysis.

2.2 DATA COLLECTION STRATEGIES

The number of samples that should be collected and analyzed depends on the objective of the investigation. There are three basic sampling strategies: random, systematic, and judgmental sampling. Each of the strategies is explained in the following:

- Random sampling involves collection of samples in a nonsystematic fashion from the entire site or a specific portion of a site.
- Systematic sampling involves collection of samples based on a grid or a pattern which has been previously established.
- Judgmental sampling involves collection of samples only from the portion of the site most likely to be contaminated.

A combination of these strategies is the best approach depending on the type of the suspected/known contamination, the uniformity and size of the site, and the level/type of information desired.

2.3 SAMPLE LOCATION DOCUMENTATION

Once a sample location is chosen and the sample has been collected, the location will be temporarily staked or marked until it has been surveyed. Additionally, 3 to 4 photos of the location should be taken so the location is well documented. The photos should be documented on a photo log (SOP 1.0 – Field Documentation and Sample Handling).

Wooden stakes, steel fence posts with safety caps, survey whiskers, pin flags with the name of the location written in permanent marker, or survey whiskers can be driven into the ground to show the location. It is not recommended that spray paint be used to mark locations as it may get washed off or brushed over by dirt and rocks. Spray paint may be used as a temporary location marker; however, the spray paint marker should either be surveyed or replaced as soon as possible so the location is not lost.



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Sample Collection and Data Collection Techniques

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For samples and activities that require high accuracy survey data such as the installation of borings for subsurface mapping, the installation of monitoring wells and piezometers for water level measurement, and the installation of surface monitoring monuments, survey activities will be subcontracted to a third party that has a current California survey license and is capable to surveying within a 100th of a foot. All surveys shall be completed using the most recent version of the State Plane Coordinate System. The surveyor will obtain accurate coordinates and elevations of the sample locations within several weeks after the installation activities.

If only sub-meter accuracy for vertical and horizontal survey information is needed, a hand-held GPS device may be used in place of a licensed surveyor to obtain general coordinates of locations and activities.



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1.4 REVISION LOG

Revision Number	Author	Description of Change (Section number)	Date



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3.0 - FIELD MEASUREMENTS - WATER

Purpose and Scope: The purpose of this document is to provide procedures for measuring

the water levels from wells and collecting field parameters in surface water and groundwater. It includes instructions on the setup, field

procedures, and how to fill out the associated field forms.

Equipment: pH

pH Meter and Electrode

Specific Electrical Conductance (SEC) Meter

Dissolved Oxygen (DO) Meter

Oxidation Reduction Potential (ORP) Meter

Thermometer or Temperature Probe

Fluorometer

Fluorometer Sample Analysis Cuvette

Spectrophotometer and associated sample vials and reagents

Peristaltic Pump

0.45-micron Large Capacity Filter Cartridges

Silicone Tubing
Polyethylene Tubing
Distilled Water
Deionized Water
Spray Water Bottles
1% Liquinox Solution
Sample Cup or Beaker

Calibration Standards for Each Meter

Miscellaneous Field Tools:

Socket for Flush Mounted Wells

Cutting Shears

Spare Combination Locks Christie Box Opening Tool Flat Head Screwdriver

Extra Batteries Nitrile Gloves

Documentation:

Daily Field Record (DFR)

Water Level Monitoring Record (attached)
Well Development Record (attached)
Well Sampling Record (attached)

Micro-Purge Sampling Record (attached)

Boring Grab Groundwater Sampling Record (attached)

General Water Sampling Record (attached)

Multi Parameter Meter Calibration Sheet (attached)

Single Point Calibration Sheet (attached)



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This Standard Operating Procedure (SOP) describes the general methodology for water level measurement from wells and measuring field parameters in water. Field parameters typically consist of pH, specific electrical conductance (SEC), turbidity, oxidation-reduction potential (ORP), temperature, and dissolved oxygen (DO). Alkalinity, dissolved zinc, and sulfate may also be measured in the field. Refer to the manufacturer's recommendations for specific operational procedures and calibration requirements for each type of field instrumentation and field analytical method described in this SOP.

All field measurements of water will be performed by appropriately trained field staff under the guidance of a California-licensed Professional Geologist or Professional Engineer.

This SOP is to be used in conjunction with the Sampling and Analysis Plan (SAP) and associated work plans.

3.1 SET-UP AND EQUIPMENT CALIBRATION

Prior to taking any field measurements, sampling personnel will assemble all necessary equipment and calibration standards. All instruments to be used will be checked and calibrated per the manufacturer's instructions and as often as recommended by the manufacturer to ensure they are in proper working condition. Calibration data including the concentration of the calibration standard(s) and the calibration reading for the check standard(s) will be recorded on a Multi Parameter Meter Calibration Sheet, and/or a Single Point Calibration Sheet, as applicable (attached).

3.2 WATER LEVEL MEASUREMENT

Water levels may be measured in monitoring wells, piezometers, and water supply wells or in other types of structures where water can accumulate (e.g. mine shafts). For ease of use, "well" will refer to any structure in which the water level is being measured. Open the well by removing the lid on the well box and remove the well cap. When opening the well box and removing the cap, be sure to keep your head away from the top of the open casing to avoid inhaling any fumes that may reside within the well.

Decontaminate all water level measurement equipment as described in SOP 4.0 – Equipment Decontamination prior to inserting any instruments into the well.

Water level measurements will be referenced to a known elevation datum. The measuring point at the top of the well casing (generally the north side of the casing) or some other permanent



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reference point will be permanently marked and surveyed. Measurements will be consistently taken from the same marked point. Water levels will be measured with an electrical sounding device, a hydrocarbon interface measuring device, or equivalent device.

The static water level will be measured in each well using an electronic water level indicator. Measurements will be made by recording the depth-to-water (DTW) and repeating the measurement until at least two consecutive depth readings within 0.01-foot are measured. The final water level measurement for each well will be recorded in the field on a Water Level Monitoring Record.

When attempting to collect a DTW measurement, if a vacuum or a pressure buildup is detected upon opening the airtight well cap, an initial depth to water level will be obtained and the well will be allowed to equilibrate for approximately 3-5 minutes. After the field geologist or engineer has used professional judgment to determine that the water table is stable, another DTW measurement within the well will be obtained. Additional measurements will be obtained at 3-5 minute intervals until at least two consecutive depth readings are within 0.01-foot.

The field geologist or engineer may also measure the depth-to-bottom (DTB), or the depth to the bottom of the well by lowering a measuring device (e.g., sounding device) to the bottom of the well. If the sounding device has a "zero measuring point" at a place other than the tip of the probe, the difference in measurement will be added or subtracted from the reading so that the recorded value is an accurate measurement from top of casing to DTB.

At the completion of the DTW and possible DTB measurements, the field geologist or engineer will wipe down the down-hole equipment with a new paper towel to remove excess water or debris from the tool and decontaminate as appropriate.

3.3 FIELD PARAMETERS

Generally, a multi-parameter water quality meter (YSI is the brand that is commonly used) will be used to measure field parameters. The following describes measuring field parameters of pH, SEC or EC, temperature, turbidity, ORP, and DO using an YSI meter or similar equipment.

3.3.1 pH

The general procedures for the operation, calibration, and maintenance of the field pH meter and its accessories are included in the instruction manual provided with the equipment. In addition, the instruction manual provides information regarding specific calibration requirements



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and user recommendations. Manufacturer's specifications and recommendations should be followed when using the pH meter.

Prior to use each day, the pH meter should be examined for cleanliness, for defects, and for any possible need of repair. The examination should include the battery and electrode. Once the pH meter is observed to be in correct operating condition, it should be calibrated using a minimum of a three-point calibration using 4.0, 7.0, and 10.0 pH standard solutions (purchased from a reputable vendor, and non-expired). Prior to beginning the calibration, the expiration date for each of the calibration standards will be checked. Standard solutions that have expired will not be used and will be properly disposed in accordance with SOP 5.0 -- IDW Disposal. A record of the pH reading for each concentration of standard and any calibration notes will be denoted on the Multi Parameter Meter Calibration Sheet.

3.3.2 Specific Electrical Conductance

The general operation, calibration, and maintenance for use of the SEC meter are included in the instruction manual provided with the equipment. In addition, the instruction manual provides information regarding specific calibration requirements and user recommendations. Manufacturer's specifications and recommendations should be followed when using the conductivity meter.

Prior to use each day, the SEC meter should be examined for cleanliness, for defects, and for possible need of repair. The examination should include the battery and the probe. Once the conductivity meter is observed to be in correct operating condition, it should be calibrated using a minimum standard solution of 1,000 micro-Siemens (μ S/cm) at 25 degrees Celsius (° C) (purchased from a reputable vendor). Prior to beginning the calibration, the expiration date for the calibration standard will be checked. Standard solutions that have expired will not be used and will be properly disposed of in accordance with SOP 5.0 – IDW Disposal. A record of SEC reading and any calibration notes will be denoted on the Multi Parameter Meter Calibration Sheet.

3.3.3 Temperature

The operation procedure of the thermometer or temperature probe for use in the field is included in the instruction manual provided with the equipment. Prior to use each day, examine the thermometer/probe for cleanliness, defects, and any possible need of repair. Temperature calibration is done by the manufacturer.



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3.3.4 Turbidity

The general procedures for the operation, calibration, and maintenance of a field turbidity meter are included in the instruction manual provided with the equipment. In addition, the instruction manual provides information regarding specific calibration requirements and user recommendations. Turbidity meters used can either be part of a multi-parameter unit or a single turbidity meter (La Motte is the brand commonly used).

Prior to use each day, the turbidity meter should be examined for cleanliness, for defects, and for possible need of repair. The examination should include the battery. Once the turbidity meter is observed to be in correct operating condition, it should be blanked with a 0.0 NTU standard solution then calibrated using a standard solution close to the expected sample range (purchased from a reputable vendor). Prior to beginning the calibration, the expiration date for each of the calibration standards will be checked. Standard solutions that have expired will not be used and will be properly disposed in accordance with SOP 5.0 – IDW Disposal. Acceptance limits for each standard and any calibration notes will be denoted on the Multi Parameter Meter Calibration Sheet.

If the turbidity meter reads in AU instead of NTU, then the sample is too turbid to collect a measurement. For documentation purposes, it should be noted that the meter is reading >500 NTU instead of noting the value in AU.

3.3.5 Oxidation-Reduction Potential

The general procedures for the operation, calibration, and maintenance of the field ORP are included in the instruction manual provided with the equipment. In addition, the instruction manual provides information regarding specific calibration requirements and user recommendations.

Prior to use, examine the ORP meter for cleanliness, defects, and any possible need of repair. The examination should include the battery and probe. Once the ORP meter is observed to be in correct operating condition, it should be calibrated using a minimum standard solution of 100 milliVolts (mV) (purchased from a reputable vendor). Prior to beginning the calibration, the expiration date for the calibration standard will be checked. Standard solutions that have expired will not be used and will be properly disposed of in accordance with SOP 5.0 – IDW Disposal. A record of the ORP reading and all calibration notes will be denoted on the Multi Parameter Meter Calibration Sheet.



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3.3.6 Dissolved Oxygen

The general procedures for the operation, calibration, and maintenance of a field DO meter are included in the instruction manual provided with the equipment. In addition, the instruction manual provides information regarding specific calibration requirements and user recommendations.

Prior to use, examine the DO meter for cleanliness, defects, and any possible need of repair. The examination should include the battery and probe. Once the DO meter is observed to be in correct operating condition, it should be calibrated using distilled water and the barometric pressure of the atmosphere where the DO is being collected. All calibration notes must be recorded on the Multi Parameter Meter Calibration Sheet.

Dissolved Oxygen is generally calibrated in percent (%) but the sample readings *MUST* be recorded in mg/L. Dissolved Oxygen levels vary based by temperature, barometric pressure, and salinity. The general saturation levels range from 8 to 14 mg/L DO. If the meter reads above the saturation level for the current temperature and pressure, it should be recalibrated. If it is still out of range, the membrane and solution should be changed.

3.3.7 Rhodamine

A field fluorometer will be used to measure rhodamine dye concentrations during pilot test tracer studies. The operation procedure for the fluorometer for use in the field is included in the instruction manual provided with the equipment. Prior to use each day, examine the fluorometer for cleanliness, defects, and any possible need of repair. The examination should include the battery and probe.

Once the fluorometer is observed to be in correct operating condition, it should be calibrated using a primary standard made from the rhodamine dye used for the tracer study. The primary standard shall be prepared using the Pond 11 discharge water diluted to approximate the anticipated rock drain inlet tracer concentration. A record of the fluorometer reading and all calibration notes shall be denoted on the Single Point Calibration Sheet.

3.3.8 Tagout

If any of the above water quality meters are found to be above or below the range of concentration for check standard, the equipment must be locked out and tagged out so it will not



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be used inadvertently. A replacement meter shall be obtained and properly calibrated while the out of range equipment is repaired.

3.3.9 Procedures for Testing a Sample

Samples will be tested for the above water quality parameters by triple rinsing a small container with the sample water before filling the container with the sample to be tested. Once the container is filled to the level in which all the appropriate probes will be submerged the probe shall be inserted into the container and the parameters shall be allowed to stabilize. If more than one meter is used then a second container shall be filled in order to submerge the second probe.

In some cases a flow through cell may be used while collecting water quality parameters. If a flow-through cell is used it must be decontaminated in between each sample location (see SOP 4.0 – Equipment Decontamination). Do not use detergents when decontaminating probes. Only rinse probes with fresh or distilled water.

Once the water quality readings have stabilized, but before the temperature of the sample begins to change (less than 5 degrees Celsius difference from the initial temperature reading) because of the ambient temperature, the values for each parameter will be recorded on the appropriate sampling record (attached).

3.4 FIELD ANALYTICAL METHODS FOR ALKALINITY, ZINC, AND SULFATE

Field measurement of alkalinity, zinc, and sulfate will be made with a HACH[®] DR 3900[™] Spectrophotometer, YSI 9300 Spectrophotometer, or comparable field instrument. The appropriate reagents and methods shall be employed for use with the specific field instrument.

Field measurement of alkalinity, zinc, and sulfate will be made with a (or similar) using Total Alkalinity),), and) respectively. Prior to use each day, the spectrophotometer should be examined for cleanliness, for defects, and for any possible need of repair. The examination should include the battery.

For the HACH® DR 3900 Spectrophotometer, the following methods and reagent sets will be used:

- Total Alkalinity: TNT870 Reagent Set, HACH® Method 10239
- Dissolved Zinc: Zinc Reagent Set, HACH® Method 8009

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Sulfate: Sulfa Ver 4[®] Powder Pillows or AccuVac[®] Ampuls, HACH[®] Method 8051

For the YSI 9300 Spectrophotometer, the following methods and reagent sets will be used:

- Total Alkalinity: YPM188 or YAP188 reagent kit; YSI Method YSIP2
- Dissolved Zinc: YPM148 or YAP148 reagent kit; YSI Method YSIP35
- Sulfate: YPM154 or YAP154 reagent kit; YSI Method YSIP32

Prior to use each day, the spectrophotometer should be examined for cleanliness, for defects, and for any possible need of repair. The examination should include the battery.

The following sections describe methods for analysis of total alkalinity, zinc, and sulfate using the HACH® DR 3900 Spectrophotometer. Spectrophotometers not manufactured by YSI should be operated and calibrated according to the manufacturer's instructions. For analysis of other constituents not described here, the appropriate methodology as developed by the manufacturer for the specific instrument shall be used.

3.4.1 TOTAL ALKALINITY

3.4.1.1 **ANALYSIS**

To measure total alkalinity, the sample will be field filtered prior to analysis to remove particles. A pipet will be used to place 2 ml aliquot of the Total Alkalinity TNT870 Reagent solution into the glass sample vial. Add 0.5 mL of sample water into the vial. The container will be inverted several times and allowed to react for five minutes using a timer. At the conclusion of five minutes, wipe off the glass sample cell with a soft clean cloth to remove finger prints or smudges which can interfere with sample reading. The instrument reads the barcode on the test vial to select the method and makes the measurements. The results are reported in mg/L of calcium carbonate (CaCO₃).

If the result is reported as 400 mg/L of $CaCO_3$ or higher, the sample is at or above the upper limit and a dilution of the sample must be performed (see Section 3.4.4 for instructions on how to dilute a sample). If the result of an un-diluted sample is reported as 25 mg/L $CaCO_3$, the sample is at or below the lower limit and should be reported as 25 mg/L.

3.4.1.2 CALIBRATION/ACCURACY CHECK

According to YSI, the colorimeter is pre-calibrated for the total alkalinity measurement; however, at a minimum, an accuracy check should be performed at least once a week. To run an



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accuracy check, a 1.0 mg/L iron solution will be used. It can be purchased at the 1.0 mg/L concentration or it can be diluted from a more concentrated stock solution.

If no dilution is necessary, the analysis procedure described in Section D6.4.1.1 will be used to test the accuracy of the instrument. Results should be between 0.9 mg/L and 1.1 mg/L Fe. All accuracy check results must be recorded on a HACH Accuracy Check Sheet.

If using a dilution to prepare the 1.0 mg/L total dissolved iron standard solution from a concentrated stock solution (example here is a 100 mg/L concentration stock solution, but other concentrations may be used as well, with appropriate dilution ratios):

- Wash a 100 mL volumetric flask with a 1% Liquinox solution. Rinse with copious amounts of deionized or distilled water (until no more bubbles are visible with agitation).
- Fill flask about halfway with deionized water.
- Using a graduated pipette, measure 1.0 mL of the purchased 100 mg/L Fe solution and add it to the clean volumetric flask.
- Carefully, bring the 100 mL graduated cylinder to volume with deionized or distilled water, cap securely and invert several times.

The solution will need to be prepared each time an accuracy check is run.

Once the solution has been prepared, the analysis procedure described in Section D6.4.1.1 will be used to test the accuracy of the instrument. Results should be between 0.9 mg/L and 1.1 mg/L Fe. All accuracy check results must be recorded on a HACH® Accuracy Check Sheet.

3.4.2 ZINC

3.4.2.1 Analysis

To measure total alkalinity, the sample will be field filtered prior to analysis to remove particles. To analyze the sample, select stored Program 780, when using the HACH® Benchtop Spectrophotometer (or other similar program depending on the instrument manufacturer). Select program by pressing the "prgm" button, followed by "780". A 25-ml graduated mixing cylinder will be filled with a 20 mL sample aliquot. Add the contents of one ZincoVer® 5 Reagent Powder Pillow to the mixing cylinder. Add a stopper to the top mixing cylinder and invert several



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times to dissolve the powder completely. The sample should be orange. If the sample is not orange (brown or blue), the zinc concentration is too high or an interfering metal is present and the sample will have to be diluted and retested (see below). If the sample does not need to be diluted, prepare a blank by pouring 10 mL of solution from the mixing cylinder into a sample cell. Then using a plastic dropper, add 0.5 mL of cyclohexanaone to the remaining solution in the mixing cylinder. Start the 30-second instrument timer to allow for the reaction to take place. During this reaction period, place the stopper onto the mixing cylinder and vigorously shake the prepared sample and start the 30-second instrument timer. The sample will be reddish-orange, brown, or blue depending on the zinc concentration. Following this reaction period, an addition three-minute reaction period will begin. Once the timer expires, pour the prepared sample solution from the mixing cylinder into a second sample cell. When the timer expires, wipe the blank sample cell with a soft clean cloth to remove finger prints or smudges which can interfere with the meter reading, insert it into the spectrophotomer, and press "zero" to zero the meter. Wipe the prepared sample cell with a soft clean cloth to remove finger prints or smudges, insert it into the spectrophotomer, and press "read" and record the results mg/L of Zn.

If the result is reported as 3.0 mg/L or higher, the sample is at or above the upper limit and a dilution of the sample must be performed (see Section 3.4.4 for instructions on how to dilute a sample). If the result of an un-diluted sample is reported as 0.01 mg/L, the sample is at or below the lower limit and should be reported as <0.01 mg/L.

3.4.3 **SULFATE (SO₄²)**

3.4.3.1 ANALYSIS

To measure sulfate, the sample will be filtered prior to analysis. The glass sample vial will first be rinsed with the sample and emptied. To analyze the sample, select stored Program 680, if using SulfaVer® 4 powder pillows, or Program 685, if using SulfaVer® 4 AccuVac® Ampuls, when using the HACH® DR 3900 Spectrophotometer (or other similar program depending on the instrument manufacturer). Select program by pressing the "prgm" button, followed by "680" (if using pillow packets) or "685" (if using AccuVac® Ampuls). A 10 ml aliquot will be transferred to the 10 mL mark in two separate glass sample cells. If a dilution is required, then both of the rinsed HACH® sample cells should be filled to the 10 mL line with diluted sample (see section 3.4.4 for instructions on how to dilute a sample). Wipe off one of the glass sample cells with a soft clean cloth to remove finger prints or smudges which can interfere with the meter reading, insert it into the colorimeter, and press "zero" to zero the meter. Add the contents of one SulfaVer® 4 powder pillow to the second sample cell and secure the cap. The container will be inverted several times and allowed to react for five minutes using a timer. At the conclusion of



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five minutes, wipe off the glass sample cell with a soft clean cloth to remove finger prints or smudges which can interfere with sample reading. Insert the sample into the spectrophotometer and press "read" and record the result.

If the result is reported as 70 mg/L of $SO_4^{2^-}$ or higher, the sample is at or above the upper limit and a dilution of the sample must be performed (see Section 3.4.4 for instructions on how to dilute a sample). If the result of an un-diluted sample is reported as 2 mg/L, the sample is at or below the lower limit and should be reported as <2 mg/L. If using the SulfaVer® 4 AccuVac® Ampuls, follow the procedures included in the instruction manual provided with the equipment. Ampoules

3.4.3.2 CALIBRATION/ACCURACY CHECK

For sulfate, a new calibration conducted by the user is recommended for each new lot of reagent; however the Standard Adjust feature is typically sufficient for field purposes.

We will perform the Accuracy Check Standard Solution Method. Use a 50 mg/L sulfate standard if available. Otherwise, prepare a 50mg/L standard solution using the following procedure:

- Wash a 100 mL volumetric flask with a 1% Liquinox solution. Rinse with copious amounts of deionized or distilled water (until no more bubbles are visible with agitation).
- Fill flask about halfway with deionized water.
- Using a graduated pipette, transfer 1.0mL of a PourRite Ampoule Standard for Sulfate (2500mg/L) to the 50mL volumetric flask (you can also transfer 2.0mL into a 100mL volumetric flask if one is available).
- Carefully bring the volume in the flask up to the line by adding deionized water. Place cap on flask and slowly invert 3 times.
- Run this solution as a sample in the method described above.

According to HACH[®], a standard adjust is recommended when using the stored programs 680 or 685. To adjust the calibration curve using the reading obtained with the 50-mg/L standard solution, run the standard as a sample as described above, press the "setup" key and scroll to the STD setup option. Press "enter" to activate the standard adjust option. Then enter "50" to



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edit the standard concentration to match that of the standard used. Press "enter" to complete the adjustment.

Refer to instrument calibration instructions for all other instrument manufacturers. If a new calibration is performed using the HACH® spectrophotometer then an accuracy check is not required. All calibration results must be recorded on the HACH® Accuracy Check Sheet.

3.4.4 SAMPLE DILUTION

Each analysis has an upper concentration limit which is listed in the manufacturer's instructions. If the initial sample reading is greater than the upper concentration limit, a dilution of the sample will be completed. A dilution of 1 part sample to 99 parts deionized water for a total of 100 parts (1:100) will be conducted first. If the resulting value is less than half the detection limit, a dilution of 1 part sample to 49 parts deionized water for a total of 50 parts (1:50) will be conducted. Fill both sample cells to the desired level with the diluted sample. Wipe off one of the glass sample cells with a soft clean cloth to remove finger prints or smudges which can interfere with the meter reading, insert it into the colorimeter, and press "zero" to zero the meter. After the meter has been zeroed, run the test following the desired analysis procedures as outlined above. The resultant value will be multiplied by 100 or 50, based on the respective dilution completed to determine an actual concentration. Record *only* the final dilution results on the Sampling Record. Write all the dilution ratios that were made on the DFR, but not the out of range results because they are not accurate and might accidently get mixed up with a correct value.



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Field Measurements – Water

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3.5 REVISION LOG

Author	Description of Change (Section number)	Date
	Author	Author Description of Change (Section number)



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ATTACHMENTS

- Water Level Monitoring Record
- Well Sampling Record
- Grab Groundwater Sampling Record
- Multi Parameter Calibration Sheet
- Single Point Calibration Sheet

WATER LEVEL MONITORING RECORD Project Name: _____ Project and Task Number: _____ Date: _____ Measured by: _____ Instrument Used: _____ Note: For you convenience, the following abbreviations may be used. P = Pumping I = Inaccessible D = Dedicated Pump WL = Water Level ST = Steel Tape ES = Electric Sounder MP = Measuring Point DTW = Depth to Water Assumed Dry = DTW Measurement Below Estimated Bottom of Screen DTB ≔ Depth to Bottom Depth to Water Level Bottom Well No. Time Remarks Below MP Below MP (feet) (feet)*

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WELL SAMPLING RECORD



Well ID:						Ini	tial Dept	h to Wat	er:			
Sample ID):					To	Total Depth of Well:					_
			nple Time: _			_ We	Well Diameter:					_
Sample D	epth:					_ Ca			culation:			
Project an	nd Task No	.:	_						– Initial D 0.652 (if 4		Vater) x 0.163 (if 2"	
Project Name:							•	•				
Date:						Ca -	Iculation	1:				
						_ 10	asing V	olume: _				_
			Sampling			- 30	asing V	olumes:				
Pump Typ	e (& disch	arge line)	:				_					-
						Το	tal Gallo	ns Remo	oved:	***		-
Time					oC /cm)	DO (mg/L)	ORP (mV)	Turbidit (NTU)	(c	Remarks color, odor, sediment, prox. purge rate, etc.)	_	
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				:		-						_
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HACH Res	sults (mg/L	.) Dilu	tion Factor	Final Re	sult: (multip	ly by 100	for 1:10	0 dilution (or 50 for	1:50 dilution, etc.)	_
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(duplicate, i	C Type rinsate blank blank)	,	QA/QC San (GWLMMDD			QA/Q Samp Time	le In	ACH QA itial Res (mg/L)	ults	ilution Factor	Final Result (mg/L)	l'
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Notes:												3
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Instrumer	nt(s) Used	(model or	unit no.):									
(see Instru	ment Calib	ration form	dated		for	calibr	ation det	ails)				_
Samplers	Name:				s	ample	ers Sign	ature:				

WELL SAMPLING RECORD



ļ.					30	Casino V	olumes:		
Date:									
Time	Depth to Water (feet btoc)	Cum. Vol. (gal.)	pH (units)	Temp. (°C)	SpC (μS/cm)	DO (mg/L)	ORP (mV)	Turbidity (NTU)	Remarks (color, odor, sediment, approx. purge rate, etc.)
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Notes:		4				•			
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GENERAL WATER SAMPLING RECORD



Location ID: Sample ID: Sample Date: Method of Sampling:					Proje	Location Type: Project and Task No.: Project Name: Sampled By:				
Time	pH (units)	Temp. SpC (°C) (μS/cm) (DO mg/L)	ORP (mV)			aarks sediment)		
HACH Resu	lts (mg/L)	Dilution Fac	ctor		imit (DL) foi				i:50 dilution, etc.)	
Alkalinity:				,				•		
Zinc:	<u> </u>	ļ								
Sulfate:										
			-	QA/QC Sam				•		
QA/QC 1 (duplicate, ri	nsate or	QA/QC (SWLMI				HACH QA/QC Initial Results (mg/L)		Dilution Factor	Final Result (mg/L)	
				-		Alkalinity:			-	
		W 1 W 1				Zinc:				
•••						Sulfate:				
Notes:	 									
										
	-							-		
										
				T =						
Duplicate C					Sample ID		<u>-</u>		e Time:	
Equip Rinsa		ollected?		Rinsate B					e Time:	
Field Blank	Collected?			Field Blan	K ID:			Samp	e Time:	
Samplers N	ame:				Sampler	s Signature				

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MULTI PARAMETER N	IETER CALIBRATION SHEET
Project Name: Task Name:	m t AN other
Equipment Type: Multi Parameter	
Manufacturer:	Owner of Meter:
Model Number:	Serial Number:
Date of Last Calibration:	
*Be sure to calibrate in the order	r listed
Calibration #1: Specific Conductance (SEC; No terr Calibration Standard:	
Instrument Reading:	
Calibration #2: pH 7 (adjust for temperature) Calibration Standard: Instrument Reading:	
Calibration #3: pH 4 (adjust for temperature) Calibration Standard: Instrument Reading:	
Calibration #4: pH 10 (adjust for temperature) Calibration Standard: Instrument Reading:	Time:
Calibration #5: ORP (adjust for temperature) Calibration Standard: Instrument Reading:	Time:
Calibration #6: DO % Calibration Standard: Instrument Reading:	Time:
Misc. Comments:	
	Calibrated by:



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4.0 - EQUIPMENT DECONTAMINATION

Purpose and Scope: The purpose of this document is to describe procedures for equipment

decontamination. It describes decontamination methods and provides specific procedures for decontaminating drilling and excavation

equipment, submersible pumps, decontamination for the collection of

equipment blanks, and water level meters.

Equipment: Steam Cleaner

Four 5-gallon buckets with lids

Bucket labels Brushes Distilled water Potable water Spray bottles Paper towels

Liquinox® or other Non-Phosphate Cleaning Solution (not Alconox®)

10 mil visqueen

Documentation: Daily Field Record (DFR)

Atlantic Richfield Chain-of-Custody (COC) Form

This Standard Operating Procedure (SOP) is to be used in conjunction with the Sampling and Analysis Plan (SAP) and applicable work plans.

4.1 DECONTAMINATION PROCEDURES

Decontamination procedures described in this section are applicable to non-dedicated, non-disposable sampling equipment. The following subsections describe the methods of decontamination and procedures for decontaminating specific types of sampling equipment.

4.1.1 Decontamination Methods

All sampling equipment must be decontaminated after it arrives onto the site and before each sampling operation. <u>This includes subcontractor equipment</u>. Decontamination onsite will use one of the methods below:

- Three-Step System
- Steam Cleaner

The procedures for decontamination using the three-step system or steam cleaner are described in the following subsections. The exception to using the three-step system or a



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steam cleaner for decontamination is when cleaning a water level meter. This is described in Section 4.1.2.4 of this SOP.

4.1.1.1 Three Step System

The three step decontamination system consists of washing the sampling equipment: (1) in soapy water using a non-phosphate (Liquinox®) solution, (2) rinsing with potable water and (3) rinsing again with distilled water. The Liquinox® solution will be mixed in accordance with the manufacturer's recommendations. Equipment will be washed in a row of three containers. Depending on the equipment to be decontaminated, spray bottles containing the applicable solutions may be used. Hard bristle bottle brushes may be used to remove mud and debris prior to the three step system with an optional fourth container. Sample equipment should be allowed to drain dry after the final distilled water rise. Decontamination water will be disposed of according to procedures described in SOP 5.0 – Investigation Derived Waste Disposal.

4.1.1.2 Steam Cleaner

The steam cleaner will be supplied by a subcontractor and operated according to the manufacturer's recommendations. It will be capable of generating a working pressure of approximately 1,500 to 2,000 pounds per square inch (psi), a discharge rate of 3 to 5 gallons per minute (gpm), and an operating temperature of approximately 130 to 150 degrees Fahrenheit (°F).

The steam cleaner will be used within a decontamination station designed to capture all of the water. The decontamination station may be mounted on a portable trailer or constructed onsite and will be supplied or built by a subcontractor. If constructed, the on-site decontamination area will be lined and bermed with two layers of 10 mil visqueen to contain rinsate from steam cleaning operations. If appropriate, the decontamination area will be designed to allow heavy equipment (backhoe, drilling rig, and support vehicles) to drive onto the visqueen. During operation of the steam cleaner, the field engineer or geologist will establish and maintain an exclusion zone. Decontamination water will be retained and disposed according to procedures described in SOP 5.0 – Investigation Derived Waste Disposal.

4.1.2 Sampling Equipment

The following subsections provide specific details for decontaminating drilling and excavation equipment, submersible pumps, equipment blanks, and water level meters.



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4.1.2.1 Drilling and Excavation Equipment

Drilling and excavating equipment, including backhoe buckets, drill bits, casing, augers, and tools or other equipment that have come in contact with potentially impacted soils or water will be cleaned between each location, as appropriate. After completion of each boring, drill casing or augers, drill bits and drill rods will be transported by truck to the steam cleaning area. Drill casing from the monitoring well drilling procedures will be lifted from the support truck and cleaned within the decontamination station. Heavy tooling with edges that can damage the decontamination area will be placed on lumber in the decontamination area for cleaning. Rinsate collected in the decontamination area will be retained and disposed according to SOP 5.0 – Investigation Derived Waste Disposal.

4.1.2.2 Submersible and Bladder Pumps

If a non-dedicated submersible pump is used, it will be cleaned prior to use and between sampling locations using the three-step system. First, the pump intake device will be submersed into non-phosphate cleaning solution (Liquinox®) and recycled within a bucket for at least 30 seconds. Second, the pump will be submersed into a bucket containing potable water and recycled within the container for at least 30 seconds. The second step should be performed sufficiently rinse the suds from the pump. The third step involves rinsing the pump within a bucket filled with distilled water using the same method as Steps 1 and 2.

If a non-dedicated bladder pump is used, it will first be disassembled and decontaminated using the three-step system. If so equipped, the disposable bladder will be removed and replaced with a new bladder. The used bladder will be disposed using project procedures for disposing solid waste. Then, the bladder pump will be assembled and rinsed with distilled water.

4.1.2.3 Equipment Blanks

As appropriate, equipment blanks will be collected after decontamination of the sampling equipment during sampling activities to provide an additional check on possible sources of contamination related to field sampling instruments. Sampling equipment (e.g., the shoe from a core sampler, hand auger, shovel, drive-sampler, etc.) will be decontaminated using the three-step system.

4.1.2.4 Water Level Meters

Water level meters will be decontaminated using a two-step system. This system consists of a spray bottle containing non-phosphate detergent (Liquinox®) mixed with water and a spray



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bottle containing distilled water. The Liquinox® solution will be mixed in accordance with the manufacturer's recommendations. The soapy water will be sprayed on the portion of the water level meter that was submerged and then rinsed by spraying distilled water until all suds are removed. The submerged portion of the water level meter will then be wiped down with a paper towel. If residual dirt or other contaminants remain on the water level meter after being rinsed, the above steps will be repeated using a brush to remove the remaining debris. Rinse water from the above procedures will be captured in a bucket or other appropriate container, labeled, and disposed in accordance with procedures described in SOP 5.0 – Investigation Derived Waste Disposal.



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4.2 REVISION LOG

Revision Number	Author	Description of Change (Section number)	Date



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5.0 - INVESTIGATION DERIVED WASTE DISPOSAL

Purpose and Scope: The purpose of this document is to present procedures for containment

and disposal of investigation derived waste such as soil, water, and

materials.

Equipment: Buckets, containers with covers for soil and water

(e.g., 55-gallon drums, 20-yard roll-off bins, Baker Tanks™)

Waste disposal labels

Appropriate sample containers and sampling equipment

Miscellaneous tools Safety Equipment

Documentation: Daily Field Record (DFR)

Waste Tracking Log (attached)

Maps/plot plan

Camera

This Standard Operating Procedure (SOP) is to be used in conjunction with the Sampling and analysis Plan (SAP) and applicable work plans.

The procedures below are to be followed for investigation derived waste consisting of water, soil, or materials such as personal protective equipment (PPE) or disposable sampling equipment. Investigation derived groundwater will be generated from well development and purging activities. Investigation derived waste water will be generated during decontamination activities. Investigation derived soil will be generated from soil borings.

All containers containing waste will be kept closed and sealed at all times unless actively adding waste. Each container must have a visible and legible label present. Labels will be constructed of weather-resistant vinyl and waterproof ink markers will be used to add information in the field. All empty containers must have a label that indicates that the container is empty. Prior to filling any waste containers, the sampler will replace the empty label with a label that describes the source of the waste (well or boring ID), the contents (soil or water), date accumulation started, date accumulation finished, and a name and contact information of the generator. The location of the waste generated will be documented on a waste tracking log (attached).

5.1 WATER DISPOSAL PROCEDURES

Groundwater produced during the well development and purging activities will be discharged to the ground surface near the well for evaporation and infiltration. Water will be discharged in a manner that prevents erosion, pooling of water, or migration to a surface water body and will be



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Investigation Derived Waste Disposal

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performed in accordance with the HSSE Program document and the TSHASP. Measures to prevent erosion or migration may consist of installing silt fencing down slope of discharge areas or transporting and land applying water in a more appropriate location. If surface discharge is not practicable or allowed, water may be containerized (e.g. in a pipe, hose, or drum) and transported to an onsite treatment system, or may be transported off-site for appropriate disposal.

Waste water produced from decontamination activities will be disposed in the same manner as described above. This includes Liquinox® (a non-phosphate detergent) that is mixed with water using the manufacturer's recommendations. Alconox® or other detergents containing phosphates will not be used on site. If other cleaning agents are used during decontamination, the field engineer or geologist will contact the Project Manager for guidance on the proper disposal procedure.

It is not anticipated that investigation-derived waste water will be transported off site.

5.2 SOIL DISPOSAL PROCEDURES

It is anticipated that most soil investigations will be performed in areas that have unconsolidated material at the surface that was left behind from previous site activities (i.e., mining, construction, landslides). Any soil or mud developed during the drilling or excavation activities are expected to have similar characteristics as the disturbed material that exists in the vicinity of the investigation. Therefore, if disturbed material already exists at the surface, any soil or mud developed during the investigation will be spread evenly in the immediate vicinity. The material will be spread in a manner that has a low profile as to prevent windblown dust from occurring. These soil disposal activities will be performed in a manner that prevents migration to a surface water body and in accordance with the HSSE Program document and the TSHASP.

If soil and mud produced during the investigation is suspected to contain other contaminants (e.g., petroleum odors, ethanol odor), the field Engineer or Geologist will contact the Project Manager for guidance. Exceptions to the above soil disposal procedures will be addressed on a case-by-case basis.

5.3 MATERIAL DISPOSAL PROCEDURES

Used PPE will be disposed in containers that are sealed and labeled. These containers will be stored onsite and later transported to an appropriate offsite disposal facility.



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Used sampling devices that have come in contact with low pH water (e.g., bailers, sample bottles) will be rinsed, cut in half, and then placed in the onsite municipal solid waste trash receptacle. The sampling devices will be rinsed with neutral pH water and the rinse water will be disposed of as specified in Section 5.1.

All other disposable equipment, including items such as rope and non-hazardous well construction materials will be disposed in the onsite municipal solid waste trash receptacle. The exception is for the disposal of equipment that has come in contact with contaminants that are suspected to be non-native to the area or those that are known to be hazardous (e.g., ethanol, diesel fuel, etc.). If this situation exists, the field engineer or geologist will contact the Project Manager for guidance.

5.4 OFFSITE FACILITY DISPOSAL PROCEDURES

Offsite disposal of investigation derived waste is not expected. However in the event that it is needed, the location and quantity of the waste that is generated will be documented on a map and Waste Tracking Log (attached).

Offsite disposal of waste will be performed in accordance with appropriate Federal, State, and local regulations. A sample of the waste to be disposed at an offsite facility will be collected and submitted to a laboratory for analysis. Analytical results of the sample will then be sent to the disposal facility where a waste profile will be generated. The profile will be reviewed and signed by a designated Atlantic Richfield representative. The U.S. EPA will then be notified of all types and quantities of waste prior to its shipment off site.

Upon approval of the waste profile, an appropriate manifest (Hazardous or Non-Hazardous) will be completed. All waste manifests will be reviewed and signed by a designated Atlantic Richfield representative. The truck driver transporting the waste will also sign and keep the manifest in his presence at all times while transporting the container to the disposal facility. The truck driver will be responsible for adhering to all Department of Transport (DOT) rules and regulations for the transport of waste on public roads.



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5.5 REVISION LOG

Revision Number	Author	Description of Change (Section number)	Date



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ATTACHMENT

Waste Tracking Log

Waste Tracking Log

Rico-Argentine Mine Site - Rico Tunnels Operable Unit OU01 Rico, Colorado



Date	Waste Type and Volume	Source Location	Container Type and Volume	Number of Containers	Storage Location

Waste Tracking Log

Rico-Argentine Mine Site - Rico Tunnels Operable Unit OU01 Rico, Colorado



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6.0 - STREAM FLOW MEASUREMENT AND SURFACE WATER SAMPLING

Purpose and Scope: The purpose of this document is to provide a general outline for

developing site specific procedures for collection of representative surface water samples measurements in small streams, small rivers or

ponds and lakes.

Equipment:

Surface Water Sample Collection Devices:

Dip sampler;

Discrete depth sampler and associated equipment;

Peristaltic pump, power supply and associated equipment;

Directional Compass;

25-foot Steel Tape and 100-foot Flexible Tape Measure;

Survey stakes, flagging, hammer;

Marking Buoys, pre-stretched line and anchors; Boat or Raft (deep River or Pond/Lake Sampling);

Appropriate Line;

USCG Approved Type III Life Vests;

Vertical Staff Gauge:

3-inch, schedule 40 PVC Pipe, length to be determined

Electronic Depth Gauge;

Volumetric Flow Measuring Structure (Weir)

V-Notch Flume

Sample containers (cleaned and provided by the laboratory);

Ice chests and blue or double bagged ice;

Tarps;

Miscellaneous tools; Safety Equipment,

Hand-Held Global Positioning System (GPS) device: and

Hip Boots and Knee-high water tight boots.



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Documentation:

Daily Field Record (DFR);

Maps;

Digital Camera and Photo Log;

Sample Control Log:

Atlantic Richfield Chain-of-Custody (COC) form or laboratory equivalent;

YSI Calibration Sheet (or other means to document instrument

calibration);

Turbidity Calibration Sheet;

General Water Sampling Form; and

Stream Flow (Discharge) Measurement Form (attached).

This SOP is to be used in conjunction with the Sampling and Analysis Plan (SAP) and applicable work plans.

6.1 STREAM FLOW MEASUREMENT

Small stream and river volumetric flow can be calculated with measurements of the stream cross-sectional area and the velocity of flow through that area using the following formula.

 $Q = V \times A$

Where,

Q = Discharge (in cubic feet per second)

V = Velocity (in feet per second)

A ≈ Area (in square feet)

The area of the cross-section through which water is flowing will be determined by one or more techniques based on the overall general size of the stream (width and depth) and water velocity. A staff gauge (graduated into feet and tenths of feet (meters and centimeters) can be used to directly measure depths of shallow streams and rivers at select points perpendicular to the stream flow. If the bottom profile of the stream or river is undulating or complicated in some manner, the sum of the volumetric flows of the individual areas making up the cross-section can determine the overall volumetric flow rate. This will require calculating the individual areas and determination of corresponding velocities in those areas. For relatively simple geometries, a simple depth measurement and velocity determination can be directly made. For complicated geometries and deep water (greater than approximately 2.5 feet) multiple velocity readings,

AMEC Environment & Infrastructure, Inc.



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using one of a number of velocity specific and calibrated electronic or magnetic flow meters will be required.

An alternative method for directly reading stream or river volumetric flows, at locations that require repeated sampling, may be to install a permanent Weir or Flume that can be used to channel flow and read volumetric flows directly. If this method is utilized, it will require plans and specifications for the design and construction of the structure.

The proper collection of representative surface water samples will also be dependent on the geometry and depths of the surface water to be sampled and the contaminant of concern. Surface water can be sampled through direct filling of contaminant specific sample containers or through collection of the sample in a pre-defined sample collection device where the sample is then transferred to the sample container. Generally, sampling of surface water from ponds and lakes do not require volumetric flows but will require knowledge of the total depth of the pond or lake and a predetermined knowledge of the depths from which samples are to be collected.

The choice of the proper location to collect a surface water sample, the method to measure areas and velocities and the proper choice of the materials of construction and type of flow meter and sample collection device is site and contaminant-specific and shall be defined in the work plans.

All work performed determining areas, velocities and collection of representative samples should be thoroughly documented on a DFR using diagrams. Photographs and a photo log will also be used to document the methods used for measuring flow.

6.1.1 Choosing a Transect Location

Stream flow measurements are performed along a transect of the stream. The transect location should include an area of moving water that can be waded and in an area of channelized flow. Hip boots or Knee-high water tight boots will be used for wading in streams. The transect location should be chosen based on a variety of general criteria ranging from point-source outfalls of concern, stream morphology, accessibility, safety concerns, and the location of preestablished sample locations. Once chosen, a transect location should be documented to provide a basis for repetition and comparison with previous or future sample events.

Stream specific criteria for selecting a transect location include looking for particular characteristics such as:



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- a well defined and stable stream bank;
- · few obstructions in the channel; and
- no eddies or still water.

Conversely, turbulent water should also be avoided, if possible. The stream should be free flowing and unrestricted by obstructions upstream or downstream, which might cause flow diversion or flow backup. A smooth streambed profile, one of relatively consistent depth across its width, is optimal. The depth of the stream must be adequate for the determination of a flow velocity and subsequent collection of the surface water sample without disturbing the stream bottom sediment.

For purposes of reproducibility, any likely movable objects within the stream bed, which may interfere with the reproducibility with subsequent sample collection events should be removed, if possible and allowable. Removal of channel obstructions, (i.e., woody debris, rocks, or other obstructions), should be performed to allowed sufficient time for stream flow re-stabilization before flow measurements are recorded.

6.1.2 Setup

Once a transect location is selected, the stream flow equipment should be laid out as close to the transect as safety allows.

- Lay out tarps near the area where readings are to be performed, one for equipment, and one for staff seating and miscellaneous supplies.
- Unload equipment and setup the workstation, allowing for easy access to needed materials.
- If contaminants are expected (such as pathogens), establish a decontamination area with another tarp where staff will be exiting the stream. Place decontamination supplies (sprayer bottles with bleach solution and distilled rinse water) in this area.
- If the banks of the stream are steep, place a ladder against the bank for safe ingress and egress.

6.1.3 Setting up the Transect

If the stream to be sampled is more than a few (five) feet across and the bottom profile of the stream is geometrically complicated, a transect for defining the area of the stream (by defined



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small sub-areas of depth) will be defined and measured in the field. The following procedures describe the process for setting up the transect.

- Setup the transect endpoints by driving a stake into the ground on each side of the stream. The resulting transect should be at right angles to the stream flow.
- Stretch a line (polyester pre-stretched line) across the stream and fasten to each stake, ensuring the line remains taut and as near the surface of the water as possible.
- Facing upstream, align the zero increment of the tape measure with the left edge of
 water and mark the line or secure the measuring tape to the line across the width of
 the stream using zip ties. If available, fasten the side of the tape measure marked in
 tenth of foot increments face-up. It may be convenient to fasten the tape measure to
 the line at the specific locations where measurements will be taken.
- Measure the total width of the stream.
- Determine the spacing of the stream velocity readings to be collected based on the width of the stream. The reading locations should be tenths of feet; equal distances apart, with 20 to 30 readings for streams wider than 20 feet, at one-foot intervals for streams between 5 and 20 feet wide, and 0.2 feet for streams less than 5 feet wide. For example, if a stream is 46 feet wide, a spacing of 2 feet (24 readings including both edges) would be preferred to a spacing of 1½ feet (30 readings). The first and last reading locations for each transect should fall at or outside the left and right edges of the water and will have zero velocity and zero depth.

If a boat or raft will be used to take the readings because the stream cannot be safely waded, the boat or raft must be stabilized against movement at each transect station but allowed to be moved across the stream as measurements dictate. A line (preferably polyester pre-stretch) tied to existing secure objects such as trees, guardrails, or other stationary objects (one on either side of the stream) should be attached to the boat through cleats, cams or eyelets on the boat or raft (and secured by appropriate knots (such as a bowline)) to enable the line to be untied. The objects should be as far upstream of the transect as the width of the stream. The lines must be independently adjustable on the boat to allow for freedom of movement along the transect yet allowing stability from downstream or lateral drift. If stationary objects are not available, vehicles, securely driven stakes, or two secure anchors on each stream bank may be necessary. Motors, if used, should not be used during actual velocity readings or sample collection.



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6.1.4 Measurement of Stream Depth

The depth of the stream should be measured at each point of the transect using equipment specific to the approximate depth encountered. For depths less than 5-feet, a staff gauge or steel measuring tape, in a vertical position, can be used to measure depth directly in feet and tenths of feet. If the velocity of the stream is too great, the turbulence around the gauge may make accurate and reproducible readings difficult. In this case, a PVC pipe, longer than the stream is deep and perforated near the bottom to allow communication with the stream flow, can be used to minimize the turbulence around the staff gauge while measuring the depth. The tube should be placed in the location of the measurement, the water level in the tube allowed to come to equilibrium and then the staff gauge used through the tube. Care should be taken to not disturb the sediment or organisms on the bottom of the stream bed.

For greater depths, a graduated measuring, and weighted, line may be used or an electronic depth meter for situations such as lakes and deep ponds.

Document the location of the measurement by using a GPS device.

6.1.5 Measurement of Stream Velocity

There are a number of velocity measuring methods/devices that can be used for determination of the stream velocity at each sampling location or at each point of a transect. The methods for velocity determination will be defined in the work plan with the prior knowledge of each sample collection point location. The procedures for the proper calibration and use of velocity meters are well defined by the US Geological Survey and other State and Federal agencies as well as manufacturers of the meters. The measurements should follow these procedures and be made by staff with experience with the meters to be used.

For streams with simple geometry and steady laminar flow, the flow may not deep enough to fully submerge any of the available flow velocity meters. In this instance a simple method for velocity determination is to measure the rate of travel of a float on the surface of the water using a defined distance along the axis of the stream an accurate stop watch. If this method is used, at least 10 repetitions of the measurement should be made and an average of the 10 velocities used in the subsequent volumetric flow determination. Regardless of stream width, a minimum of two passes of velocity measurements should be taken; once traveling left to right facing upstream, once traveling right to left facing upstream.



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For most stream flow situations that may be encountered, where the stream can be safely waded, a velocity reading should be collected at each transect location using a calibrated velocity meter such as a Pygmy meter, Price AA meter, Acoustic Doppler Meter or Marsh-McBirney electronic direct reading meter. For each of these, a vertical profile of the stream velocity, at each transect whole foot location (see above) shall be measured as follows:

- Depths ≤ 2.5 Feet: One measurement should be taken at 60% of the depth at each measurement location.
- Depths >2.5 Feet: Two measurements should be taken: at 20% and 80% of the total depth at each measurement location.

The use of these in-stream measuring devices usually includes the use of a Wading Rod, which is a tool that is designed and constructed to easily set and hold the flow meter at the desired location and the desired depth (20%, 60% or 80%) using a defined set of gradations on the Rod and instructions that accompany the meters.

6.1.6 Measurement of Flow Velocities

For all velocity readings, the Wading Rod should be kept vertical and the meter perpendicular to the flow. For those streams with multiple measurements across a transect, measure and record the velocity, move to the next location along the transect, and repeat the procedure until reaching the opposite bank. At least one measurement should be made at each pre-determined measurement point along the transect, however additional measurements along the transect can be used to help average the flow if the site conditions suggest that this is appropriate.

6.1.7 Calculating Stream Flow

Once the velocity and depth of the points along the transect have been determined, the midsection method can be used for determining the stream flow. Compute the volumetric flow in each transect increment by multiplying the averaged velocity, or single velocity in streams less than 2.5 feet deep, in each increment by the area determined for that transect increment (depth times width). Note that the first and last increments are located at the edge of the stream and have a depth and velocity of zero. Sum the volumetric flow for each increment to compute total stream flow. Record all measurements and the resulting flow in cubic feet (or cubic meters) per second on the appropriate field forms.



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6.2 SURFACE WATER SAMPLING

Preparation and execution of surface water sampling will be performed by appropriately trained field staff under the guidance of a California-licensed Professional Geologist, Hydrologist, or Professional Engineer. Surface water sampling preparation and surface water sampling techniques will be defined in the work plan and general requirements are discussed below.

6.2.1 Preparation

Prior to performing the sampling, the following tasks will be completed:

- Determine the extent of the sampling effort, the sampling methods to be employed, and which specific equipment and supplies are needed (these will be defined by the stream, lake or pond characteristics and the contaminants of concern).
- Obtain necessary sampling and monitoring equipment.
- Decontaminate all sampling equipment and ensure that it is in working order.
- Prepare scheduling and coordinate with staff, clients, and regulatory agency, if appropriate.
- Scout proposed locations to ensure accessibility and sampling feasibility.
- Use stakes, flags, or buoys to identify and mark all planned sampling locations. If required, the proposed locations may be adjusted based on site access, property, boundaries, and obstructions.

Things to consider before sampling include:

- Will the sample be collected from the shore or from a boat on the impoundment?
- What is the desired depth at which the sample is to be collected?
- What is the overall depth and flow direction of a river or stream?
- What is the chemical nature of the analyte(s) of concern? Do they float on the water surface (collect by skimming the surface) or are the miscible (soluble) and are more likely to be present at depths (collect sub-surface)?

These considerations will help to dictate the sample equipment to be used during the sample collection.



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6.2.2 Surface Water Sampling Techniques

Sampling of both aqueous and non-aqueous liquids is generally accomplished through the use of one of the following samplers or techniques:

- Dip Sampler;
- Direct Method;
- Discrete Depth Samplers;
- Peristaltic Pumps.

Sampling situations vary widely and other techniques may be available, however these sampling techniques will allow for collection of representative samples from the majority of streams, rivers, lakes and ponds.

Sample collection devices must be of a proper composition based upon the analyses to be performed. For example, devices which are free of metal surfaces should be used for collecting samples for metal analyses. The SAP and work plan will define the materials of construction that can come into contact with the water to be sampled as well as the laboratory prepared sample containers and preservatives (if any) to be used for the water samples.

6.2.2.1 Dip Sampler

A dip sampler is useful for situations where a sample is to be recovered from an outfall pipe or along a stream, lake or pond where direct access is limited. Generally a Dip sampler is a sample collection container (either open of capable of closing upon sample collection) mounted on a long pole that may be telescoping. The long handle on such a device allows access from a discrete location. Sampling procedures are as follows:

- 1. Assemble the device in accordance with the manufacturer's instructions.
- 2. Extend the device to the sample location and collect the sample.
- 3. Retrieve the sampler and transfer the sample to the appropriate sample container.

6.2.2.2 Direct Method

For streams, rivers, lakes, and other surface waters, the direct method may be utilized to collect water samples from the water surface. This method is typically not used for sampling lagoons, impoundments, or ponds where significant concentrations of contaminants are present.



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Use adequate protective clothing and gain access to the sampling station by appropriate means. For shallow stream stations, the sampler should face upstream and collect the sample upstream from where the sample personnel are standing and without disturbing sediment. Surface water samples should always be collected prior to a sediment sample at the same location. Submerge the closed sample container, open the bottle to collect the sample, and then cap the bottle while it remains under water.

When using the direct method, do not use pre-preserved sample bottles as the collection method may dilute the concentration of preservative necessary for proper sample preservation.

6.2.2.3 Discrete Depth Samplers

When samples are to be collected from discrete depths of a stream, river, lake or pond, the predetermined depths and contaminants of concern will define what specific sample collection devices should be used. There are sample collection devices that can be used to collect samples from shallow water (less than 2.5 feet) which are generally horizontal tubes (Kemmerer sampler) or deeper depths which generally use the same principal of sample collection (Van Dorn Sampler). Both samplers are lowered to the desired sampling depth and allowed to come to equilibrium with the flowing or steady water. The line which holds the sample device is connected to a spring loaded mechanism which allows the ends of the sample tube to close. The sampler is closed by sending a "messenger", typically a metal weight, down the line to the sampler where then the weight trips the spring and the sampler is closed. The following criteria should be followed:

- 1. Using a properly decontaminated sampler, set the sampling device so that the sampling end pieces are pulled away from the sampling tube, allowing water to pass through the tube.
- Lower the pre-set sampling device to the predetermined depth. This requires knowledge of the total depth at the sample location. Avoid bottom/sediment disturbance. The line holding the sampler may need to be pre-marked to ensure that the proper depth is being sampled.
- 3. When the discrete sampler bottle is at the required depth, send down the messenger to close the sampling device.
- 4. Retrieve the sampler and discharge the first 10 to 20 milliliter (mL) to clear any potential contamination of the valve. Transfer the water sample to the appropriate sample container in accordance with SOP 1.0 Field Documentation and Sample Handling and SOP 3.0 Field Measurements Water.

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- 5. Be sure to use special attachments available on some discrete samplers to distribute small volumes at low flow rates, when appropriate.
- 6. Document the surface location of the surface water sample using a GPS device.

6.2.2.4 Peristaltic Pump Samplers

A peristaltic pump can be used to collect a sample from the water column at most depths of interest in a stream or river. Tubing (the composition of which will be defined in the work plan) is lowered to the desired sample depth (using weights to ensure that the tubing is placed to the correct depth) and connected at the surface to the peristaltic pump.

Typically peristaltic pumps work to a depth of approximately 25 feet below ground surface. Because of the overlying water, deeper depths can be sampled but may not be efficient due to the low pumping rates of peristaltic pumps and the sample volume that may be needed for sample analysis. Commercially available pumps vary in size and capability, with some being designed specifically for the simultaneous collection of multiple water samples. Due to the various pumps available no universal sampling procedure is available and the sampler should follow the procedures provided in the instruction manual for the pump.



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6.3 REVISION LOG

Revision Number	Author	Description of Change (Section number)	

ATTACHMENTS

Stream Flow (Discharge) Measurement Form



Stream Flow (Discharge) Measurement Form

Site Description				GPS ID	•				
Stream				Date/Time					
Samplers Present				Weather	Weather				
Stream width (10'	upstream)			Stream de	oth (10' upstream)				
Stream width (10'	downstream)			Stream de	oth (10' downstream)				
Other Notes:									
[
Bucket method:	Bucket volume	(gal):							
Fill Times (sec):	1)	2)	3)	4)	5)				
	6)	7)	8)	9)	10)				
Calculated discha	rge:	gpm							
divide gpm by 448	3.8:	cfs							
		_							
Flume method:	Flume type:		Estimated lo	sses around flu	me (%):				
1	Flume choke w	ridth:							
Measure	ements:	1)	2)	Other Flum	e Installation Notes:				
Upstream Stage (0.1ft):								
Downstream Stage (0.1ft):									
Lookup discharge	(cfs):								
Final Discharge in	cluding								
Estimated Losses	(cfs):								
Flow Motor moth	od:	Floui Meter	Type:						

Pass 1 Calculated Discharge (cfs): Average Discharge (cfs):

Pass 2 Calculated Discharge (cfs):

Average Discharge (crs):								
Pass 1 Flow computer datafile: Direction facing upstream; circle (R to L) (L to R)			Pass 2					
			Flow computer datafile: Direction facing upstream; circle (R to L) (L to R)					
							Tape (0.1 ft)	Depth (0.1 ft)
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Standard Operating Procedures

Rock Drain Matrix Field Sampling and Laboratory Procedures

SOP No.: 7.0 Revision: 0 Page 1 of 3

7.0 - ROCK DRAIN MATRIX FIELD SAMPLING AND LABORATORY PROCEDURES

Purpose and Scope: The purpose of this document is to provide procedures for collecting

and analyzing rock drain matrix samples for total metals analysis. It includes instructions on the setup, field sampling procedures, leachate

processing, and completion of associated field forms.

Equipment:

Sealable sample collection bags (1 Liter)

500 mL glass beaker 200 mL glass beaker 200 mL pipette

Scale Oven

Thermometer
Distilled water
Deionized water
Spray water bottles
1% Liquinox® solution

Sample bottles Sample labels Custody seals

Fine-tipped permanent markers

Sealable storage bags

Bubble wrap or appropriate packing materials

Blue ice or double bagged ice

Coolers suitable for sample shipment and holding ice

Strapping/packaging tape and shipping labels Camera with spare memory chip and batteries

Miscellaneous Field Tools: Christie Box Opening Tool

Nitrile Gloves

Documentation:

Daily Field Record (DFR)

Sample Control Log Maps/Plot Plan

Camera

Photograph Log

This Standard Operating Procedure (SOP) describes the general methodology for collecting rock drain matrix samples and preparing the rock matrix coating leachate samples for total metals analysis. This SOP shall be used in conjunction with the Sampling and Analysis Plan (SAP) and Work Plan.



Standard Operating Procedures
Rock Drain Matrix Field Sampling and Laboratory Procedures

SOP No.: 7.0 Revision: 0 Page 2 of 3

7.1 SET-UP

Prior to collecting or analyzing any samples, personnel shall assemble all necessary equipment. All field sampling activities shall be performed by appropriately trained personnel under the guidance of a California- or Colorado-licensed Professional Geologist or Professional Engineer.

7.2 FIELD SAMPLING

Prior to sample collection, field personnel shall don appropriate personal protective equipment (PPE) in accordance with the TSHASP. Field personnel shall collect approximately 500 grams of rock (approximately 20 to 25 rocks) from each of 12 locations along three transects spaced approximately evenly across the rock drain. Rock samples shall be placed in new, unused, sealable plastic bags, labeled appropriately, packaged, and shipped to the selected analytical laboratory for leachate processing and analysis of total metals by ICP. Care should be taken to remove debris from the rock sample so that samples consist primarily of rock. Sample information shall be obtained in accordance with SOP 1 – Field Documentation and Sample Handling.

7.3 LABORATORY SAMPLE PREPARATION AND ANALYSIS

Rock sample leachate shall be obtained and analyzed for each sample as follows.

- 1. Weigh an empty, clean, 500 mL glass beaker to obtain a tare weight.
- 2. Remove approximately 200 grams of rocks (10-12 rocks) from the plastic bag and place them in the 500 mL glass beaker.
- 3. Weigh the sample and beaker and note the sample mass.
- Add 150 mL of 1 molar NH₂OH·HCl solution in 0.25% glacial acetic acid to the sample and beaker.
- Cover the beaker with a distillation glass and heat for four hours at 85 degrees Celsius (°C), stirring the solution every 20 minutes and periodically confirming the temperature.
- Decant the leachate into a 200 mL glass beaker, and record the volume of liquid recovered.
- 7. Proceed with standard analytical methods for ICP metals analysis.



Standard Operating Procedures
Rock Drain Matrix Field Sampling and Laboratory Procedures

SOP No.: 7.0 Revision: 0 Page 3 of 3

8. All materials or equipment that contacts the rock samples, NH₂OH·HCl solution, glacial acetic acid, or leachate shall be properly disposed or decontaminated in accordance with applicable federal, state, and local regulations.

7.4 REVISION LOG

Revision	Author	Description of Change (Section number)	Date
Number			



Standard Operating Procedures
Wetland Organic Matrix Field Sampling and Laboratory Procedures

SOP No.: 8.0 Revision: 0 Page 1 of 3

8.0 - WETLAND ORGANIC MATRIX FIELD SAMPLING AND LABORATORY PROCEDURES

Purpose and Scope: The purpose of this document is to provide procedures for collecting

and analyzing wetland organic matrix samples for total metals analysis. It includes instructions on the setup, field sampling procedures, and

digestion and filtrate processing.

Equipment:

Sealable sample collection bags (1 Liter)

500 mL glass beakers (three)

250 mL pipette

Scale

Distilled water
Deionized water
Spray water bottles
1% Liquinox® solution

Sample bottles Sample labels Custody seals

Fine-tipped permanent markers

Sealable storage bags

Bubble wrap or appropriate packing materials

Blue ice or double bagged ice

Coolers suitable for sample shipment and holding ice

Strapping/packaging tape and shipping labels Camera with spare memory chip and batteries

Miscellaneous Field Tools: Christie Box Opening Tool

Nitrile Gloves

Documentation:

Daily Field Record (DFR)

Sample Control Log Maps/Plot Plan

Camera

Photograph Log

This Standard Operating Procedure (SOP) describes the general methodology for collecting wetland organic matrix samples and preparing the matrix digestion/filtrate samples for total metals analysis. This SOP shall be used in conjunction with the Sampling and Analysis Plan (SAP) and Work Plan.



Standard Operating Procedures
Wetland Organic Matrix Field Sampling and Laboratory Procedures

SOP No.: 8.0 Revision: 0 Page 2 of 3

8.1 SET-UP

Prior to collecting or analyzing any samples, personnel shall assemble all necessary equipment. All field sampling activities shall be performed by appropriately trained personnel under the guidance of a California- or Colorado-licensed Professional Geologist or Professional Engineer.

8.2 FIELD SAMPLING

Prior to sample collection, field personnel shall don appropriate personal protective equipment (PPE) in accordance with the TSHASP. Field personnel shall collect approximately 500 grams of wetland matrix substrate from each of 12 locations along three transects spaced approximately evenly across the constructed wetland. Wetland matrix substrate samples shall be placed in new, unused, sealable plastic bags, labeled appropriately, packaged, and shipped to the selected analytical laboratory for digestion and analysis of total metals by ICP. Sample information shall be obtained in accordance with SOP 1 – Field Documentation and Sample Handling.

8.3 LABORATORY SAMPLE PREPARATION AND ANALYSIS

Wetland matrix substrate digestion shall be conducted and analyzed for each sample as follows. The digest shall be performed in a ventilated fume hood, as it is possible that toxic hydrogen sulfide fumes will be released during the digestion.

- 1. Weigh an empty, clean, 500 mL glass beaker to obtain a tare weight.
- 2. Remove approximately 100 grams of the sample material from the plastic bag and place in the 500 mL glass beaker.
- 3. Weigh the sample and beaker and note the sample mass.
- 4. Add 200 mL of 6 molar cold hydrochloric acid (HCl) to the sample and beaker and digest for one hour, stirring digest every 20 minutes.
- 5. Decant the digest into a 500 mL glass beaker.
- 6. Filter the digest using a paper filter, and record the filtrate volume. Discard the used filter.
- 7. Proceed with standard analytical methods for ICP metals analysis.



Standard Operating Procedures Wetland Organic Matrix Field Sampling and Laboratory Procedures SOP No.: 8.0 Revision: 0 Page 3 of 3

8. All materials or equipment that contacts the wetland organic substrate, H₂O₂, HNO₃, digest, or filtrate shall be properly disposed or decontaminated in accordance with applicable federal, state, and local regulations.

8.4 REVISION LOG

Revision Author		Description of Change (Section number)	Date
Number			